ANDERSON DEPOSITION EXHIBIT 1

UNITED STATES DISTRICT COURT
DISTRICT OF MAINE

ED FRIEDMAN	)	
	)	
	)	
Plaintiff,	)	
	)	CIVIL ACTION
v.	)	
	)	Case No. 20-cv-00237-JDL
CENTRAL MAINE POWER COMPANY,	)	
	)	
	)	
Defendant.	)	

NOTICE TO TAKE ORAL DEPOSITION OF ERIK A. ANDERSON, P.E.

TO: Erik A. Anderson, P.E.

c/o William Most, Esq.
Law Offices of William Most
201 St. Charles Avenue
New Orleans, LA 70170

c/o Bruce M. Merrill, Esq.
225 Commercial Street, Suite 501
Portland, ME 04101

Please take notice that on Wednesday, January 26, 2022, via the online platform Zoom, Defendant in the above-entitled action will take the deposition of Erik A. Anderson, P.E., beginning at 10:00 a.m., upon oral examination pursuant to the Federal Rules of Civil Procedure, before The Reporting Group, or some other officer duly authorized by law to administer oaths, and will be recorded stenographically.

The deponent is requested to produce for inspection and copying at the deposition the following documents:

1. A current curriculum vitae;

2. Any and all documents reviewed, referred to, or relied upon by the deponent in forming his opinion in regards to the above-captioned matter;

3. Any and all documents including but not limited to any reports, prepared or created by the deponent, in regards to the above-captioned matter.

4. A list of all publications authored by the deponent within the past ten years.

5. A list of all cases in which the deponent has testified as an expert witness within the past ten years.

6. All documents pertaining to any charges or payments for the services of the deponent as an expert witness in this case.

You are invited to attend and cross-examine.

Please provide The Reporting Group with your contact information and email address so that an email invitation can be sent to you and/or your representatives a link to Zoom to participate in this deposition. The Reporting Group can be reached at (207) 281-4230 or thereportinggroupmaine@gmail.com.

Dated at Portland, Maine this 5th day of January, 2022.

Christopher C. Taintor, Esq.
Russell B. Pierce, Jr., Esq.
Attorneys for Defendant
Central Maine Power

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ANDERSON DEPOSITION EXHIBIT 2

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Professional Engineering Report

File Name:	**Smart Meter / Ed Friedman**
Court File Number:	**2:20-cv-00237-JDL**
Our File Number:	**2021341**
Property Address:	**Bowdoinham, Maine**
Prepared By:	**Erik S. Anderson, P.E.**
Prepared For:	**William Most, Esq.** **Law offices of William Most** **201 St. Charles Avenue** **New Orleans, LA 70170** **E-mail: williammost@gmail.com**
Issue Date:	**December 3, 2021**

Introduction

On September 26, 2021, I was contacted by Mr. Ed Friedman and requested to assist him in determining the ability / propensity of the smart meter used by Central Maine Power ("CMP") to produce radio frequency ("RF") electromagnetic waves and other electromagnetic interference "noise" and distribute that RF and electromagnetic interference ("EMI") on the power system and distribution network of his residence.

Mr. Friedman is the plaintiff in a civil action against CMP regarding the added cost that CMP charges for the use of an analog electrical power meter. Mr. Friedman has lymphoma and has been advised, due to the illness, that he should avoid any unnecessary sources of electromagnetic waves.

In summary and as explained further below, it is my opinion that:

1. The Landis + Gyr FOCUS AX SecureMesh DDX Electric [Smart] Meter and the GE (Aclara) I-210 + c SecureMesh DDX Electric [Smart] Meter used by CMP create RF electromagnetic fields / waves through their switch mode power supply's ("SMPS") and while transmitting a signal.
2. The analog electric meters used by CMP do not create RF electromagnetic fields / waves since they do not employ a SMPS and they do not transmit a signal.
3. The RF electromagnetic fields / waves produced by the electric smart meters used by CMP are not attenuated as they travel throughout the electrical distribution network of the residence the meter is controlling.
4. The use of EMI shielding technology and filters would reduce the RF electromagnetic fields / waves produced by the CMP smart meters.[1]
5. The implementation of a power supply other than SMPS power supply would reduce the RF electromagnetic fields / waves produced by the CMP smart meters.
6. The cost of integrating EMI shielding technology and non-RF generating power supplies is minimal in comparison to the cost of the smart meter.

Qualifications

I have a Bachelor of Science degree in Electrical and Electronic Engineering from North Dakota State University, located in Fargo, North Dakota. I own and operate Anderson Engineering of New Prague, headquartered in rural New Prague, Minnesota. I have owned and operated Anderson Engineering since 1987.

Anderson Engineering is a diverse engineering firm. Anderson engineering works in the forensic field performing root cause failure analysis involving electrical devices. The failures often result in economic loss, personal injury, or wrongful death. The types of losses include fires, accidents, electric shock and electrocution.

Anderson engineering manufactures current transformers under the brand name Midwest Current Transformer. Midwest Current Transformer manufactures current transformers that are an Underwriters Laboratory (UL) Recognized Component in the United States and Canada. I have designed many of the products offered by Midwest Current Transformer.

As a designer and manufacturer of transformers, their operation is one of my main areas of expertise. Switch Mode Power Supply ("SMPS") modules used by smart and digital meters are merely another type of transformer. I have investigated the involvement of the operation of the SMPS in these meters and their involvement in the creation of radio frequency ("RF") emissions.

Anderson engineering performs electrical design work and analysis for devices and electrical systems for commercial buildings. I have consulted with manufacturers and electrical designers regarding their products and designs. I have designed the electrical system for an elementary school.

[1] Kavanaugh, Jack. EMI Shielding Technology: The Industries It Touches and Why You Should Care. Forbes.com, November 11, 2021.

Anderson engineering certifies Industrial Equipment per the National Fire Protection Association ("NFPA") 70 and 79, and Underwriters Laboratory ("UL") 508. I have performed multiple inspections of industrial equipment in the field and at manufacturing facilities internationally to certify industrial equipment. Anderson Engineering also performs fire investigation to determine the cause of fires. I am a certified fire and explosion investigator with the National Association of Fire Investigators and have investigated thousands of fires.

I am a member of the American Society of Heating, Refrigerating and Air-Conditioning Engineers ("ASHRAE"). I am an active member of ASHRAE Standing Standards Project Committee ("SSPC") 41 Standard Methods for Measurements. SSPC 41 oversees the writing of various published ASHRAE standards through their subcommittees. ASHRAE SSPC 41 encompasses Standards 41.1, 41.2, 41.3, 41.4, 41.6, 41.7, 41.8, 41.9, 41.11 and 41.13. I am an active member and participant in all the Subcommittees for SSPC 41. I currently chair Subcommittee 41.1 – 2020, Standard Methods for Temperature Measurements. I am also an active member of other technical committees with ASHRAE.

I am a licensed Professional Engineer in the States of Minnesota, Illinois, Arizona, Wisconsin, Indiana, Iowa, New Mexico, Texas, Louisiana, California, Kentucky, Michigan, and Nevada. I am a Class A Master Electrician in the State of Minnesota. I am a Private Investigator in the States of Minnesota and Arizona, and I am a Private Detective in the State of Illinois. I have investigator and detective licenses in conjunction with my work as a fire cause and origin investigator.

Documents Supplied & Reviewed

I have reviewed the following documents to assist me in formulating my opinions:

See Attachment 1.

Compensation / Sworn Testimony

I am currently compensated for my forensic work at a rate of $295 per hour for standard work, and at a rate of $395 per hour for sworn testimony.

I have given sworn testimony in court or through depositions in the following cases for the last four years.

See Attachment 2.

Analysis / Discussion

Smart Meter Operation:

Smart meters create intense exposure to pulsed radio frequencies ("RF") in a few ways. RF antennas are embedded within the smart meter to transmit data usage to utility companies and/or to communicate with other smart meters or with other "smart" devices like home

thermostats. These antennas emit pulsed RF radiation. The meters various radiofrequencies emitted by these antennas also conduct through the home electric wiring. RF "wire conducted" frequencies come also from the conversion process from alternating current ("AC") to direct current ("DC") handled by the Switch Mode Power Supply ("SMPS").[2] The SMPS power the smart electric meters.

Non-transmitting digital meters also use SMPS, and therefore they too create RF, even though they do not contain a transmitting RF antenna for communications. These radio frequencies are transmitted on the residence's electrical distribution system and conduct over the internal wiring, thereby turning the home wiring into a whole-house antenna.

RF Emissions from the Transmitting Antennas:

The RF antennas that wirelessly transmit the consumer's electrical power usage data to the utility company typically use frequencies in the 900 MHz and 2.45 GHz ranges. CMP meters use approximately 2.45 GHz. These emissions are intense and can occur often, up to 190,000 times a day.[3] From my experience and testing done by others, these meters transmit more times than the electric companies report. This can easily be shown by measuring the emissions with a simple RF meter.

"Isotrope Wireless,"[4] which provides industry and municipalities with design, specification, evaluation, and construction support for wireless facilities, tested smart meters in three houses.[5] This testing showed that RF emissions from the smart meters' transmitting antennas could be detected throughout the house and were "well above" the ambient RF radiation levels.[6] These pulsed RF emissions exceed the absolute energy output limits[7] stated in Federal Communications Commission ("FCC") guidelines (if the emissions are not averaged over a 30-minute exposure as prescribed by those guidelines).[8]

RF from Wireless Antennas Enter the House's Electrical System:

The Isotrope testing also showed that the house's electrical wiring conducted substantial levels of the RF emissions at 915 MHz – the communications-related frequency for those meters[9] (in NYS) – and this frequency was then radiated from outlets (electrical power

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[2] In some meters the conversion is done using capacitators instead of SMPS.
[3] Sage Associates. Assessment of Radiofrequency Microwave Radiation Emissions from Smart Meters. January 1, 2011.
[4] https://www.isotrope.im/about-2/.
[5] Isotope Wireless. Report on Examination of Selected Sources of Electromagnetic Fields at Selected Residences in Hastings-on-Hudson. November 23, 2013.
[6] Isotrope Wireless. Report on Examination of Selected Sources of Electromagnetic Fields at Selected Residences in Hastings-on-Hudson. November 23, 2013. Page 12.
[7] Sage Associates. Assessment of Radiofrequency Microwave Radiation Emissions from Smart Meters. January 1, 2011. Page 3.
[8] On August 13, 2021, the Court of Appeals for the DC Circuit ruled that the FCC's 2019 decision that its guidelines adequately protect the public's health are arbitrary, capricious and not evidence-based. The Children's Health Defense is a Petitioner in this case. *Envtl. Health Tr., et al v. FCC*, Nos. 20-1025, 20-1138, 2021 U.S. App. LEXIS 24138 (D.C. Cir. Aug. 13, 2021). The opinion specifically questioned whether the FCC's testing procedures adequately captured the effect of pulsation or modulation. 2021 U.S. App. LEXIS 24138, *12, *29.
[9] Smart meters use a variety of frequencies for communications depending on the manufacturer's choice. PECO's meters operate at around 901 MHz. They also contain a "Zigbee" antenna that can be turned on and then communicate with nearby wireless smart devices. Zigbee uses 2400 MHz band.

delivery points) and along the house wiring (branch circuitry). The electric smart meter is connected to the incoming power lines of the home. The power to run the electric smart meter is derived from the power lines connected to the home. The RF noise generated by the electric smart meter is then transmitted along the electrical wiring within the home along with the supplied electrical power. The wiring of the home acts as a direct transmitter of the RF noise and as an antenna broadcasting the RF noise. In this fashion, the wiring within the home becomes a whole house antenna for the RF noise.

Thus, the pulsed RF emissions from the smart meter's transmitting antenna not only enter the house wirelessly through the air, but also enter into, and are conducted along, the home's electrical wiring.

RF "Noise" From the Switch Mode Power Supply:

Other RF frequencies, besides the RFs from the transmitting antennas, also enter the house electric system. In my testing I have witnessed and analyzed smart meters' effects on the incoming electrical power voltage waveform. These frequencies are a byproduct of the AC/DC conversion process which is done by the Switch Mode Power Supply ("SMPS"). The conversion process is necessary because the utility service delivers alternating current whereas the electrical components in smart meters use direct current.[10]

SMPS converts the 240 Volt AC power coming into the meter from the main power transformer, into the much lower DC voltage that the electronic devices require to function. The rapid back-and-forth conversion process used to remove the "alternating" aspect creates *unintended* RF frequencies. The on/off, back-and-forth, pulses can occur up to 150,000 times per second, which means frequencies of up to 150,000 Hz (150 KHz[11]), are created. These kilohertz frequencies are within the RF band of frequencies.[12] Most of the observed "noise" spikes are in the range of 2 to 50 kHz (2,000 to 50,000 Hz). The switching RF "spikes" are variable, and they are being imposed on the 60 Hz house electricity waveform[13] creating significant unintended RF "noise." The RF "noise" distorts power quality and can also be described as "dirty" electrical power or "dirty" electricity.

These frequencies are present all the time but are worse when less electricity is being used (e.g., at night) and when the smart meter's electronics need more power, for example, when transmitting RF bursts to the utility. These RF transmission bursts cause spikes over the electric wiring, and they are created because the SMPS has to suddenly supply more DC power.

Digital Meters Use SMPS and Therefore Also Created Unintended RF:

Digital meters also use SMPS. Therefore, even though they do not contain an RF communications antenna, the AC/DC conversion process creates significant and variable RF spikes over the electrical wiring, which is then radiated into the house. The SMPS circuit is lacking effective ground references, lightning protection and "common mode"

[10] Smart meters also rely on AC for some of the non-electronic functions they perform.

[11] 1,000 Hz is a kilohertz ("KHz"). 1,000,000 Hz is a megahertz ("MHz"). 1,000,000,000 Hz is a gigahertz ("GHz").

[12] FCC defines RF as frequencies between 3 KHz – 300 GHz.

[13] Electricity comes to the house at a frequency of 60 Hz.

electromagnetic interference ("EMI") filters. The circuit boards are lacking a direct local connection to zero voltage potential ground at the meter to sink (ground) the current and voltage oscillations of the circuit boards.[14]

Filtering and EMI shielding are design options available to CMP. The use of filters and EMI shields are not cost prohibitive.

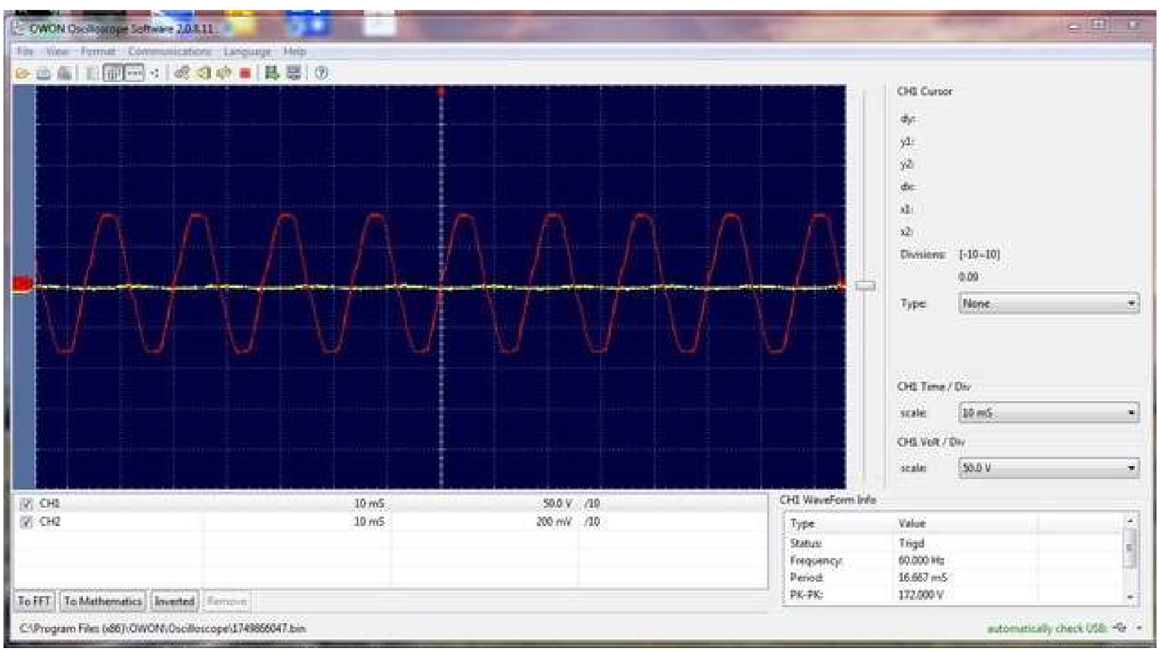
Analog Meters Do Not Have SMPS and Do Not Create RF Spikes:

In contrast, unlike wireless smart meters and digital meters, analog meters do not contain an SMPS or other electronic components that create unintended RF frequencies. No AC/DC conversion is necessary, and unlike smart and digital meters, analog meters incorporate a separate grounding electrode conductor / grounding rod that eliminates much of the "noise" that may come from the energy feed.

The images below compare a smart meter like that used by PECO[15] and similar to the one used by CMP with an analog meter. The red waveform is the 60 Hz house electricity frequency. The yellow waveform indicates the RF frequencies imposed over the 60 Hz.

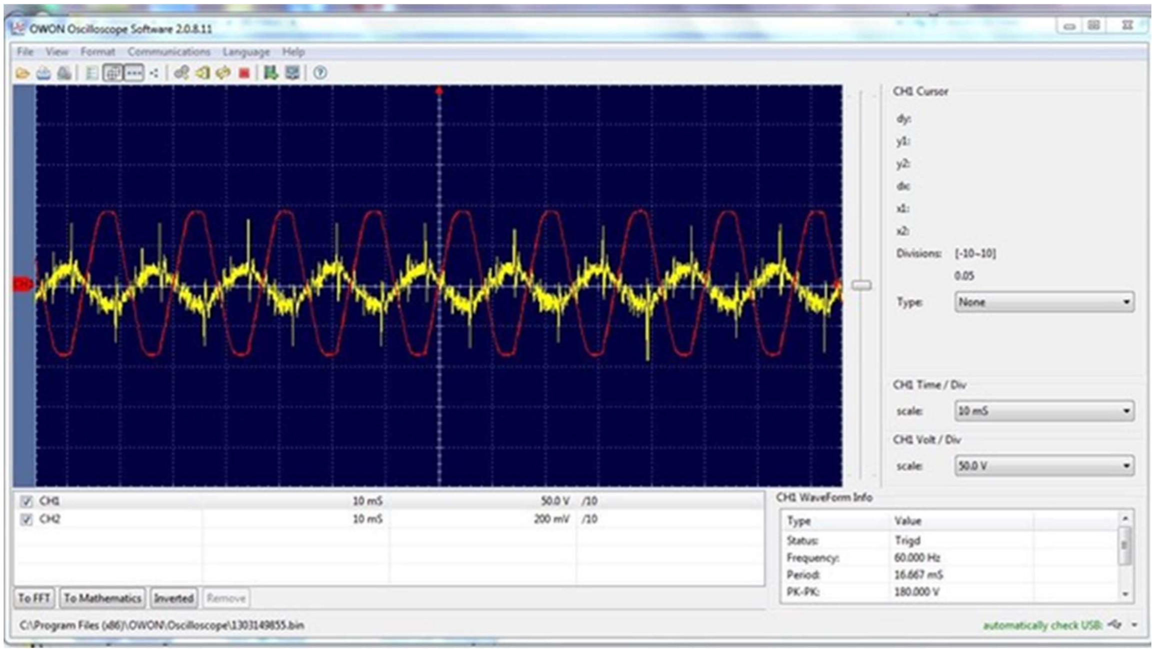
Image 1 shows that an analog meter does not create RF spikes. **Image 2** shows the smart meter causing significant RF spikes "noise" over the 60 Hz frequency house electric wiring system.[16]

Image 1: Analog Meter – No RF Spikes



[14] https://smartmeterharm.org/2019/05/31/electrical-engineer-the-meter-itself-is-the-hazardous-condition/
[15] Expert Report of William Bathgate, McKnight v. PECO, C-2017-2621057. March 26, 2018. Pages 17-18.
[16] Expert Report of William Bathgate, McKnight v. PECO, C-2017-2621057. March 26, 2018. Page 14.

Image 2: Smart Meter – Intense RF spikes.



My Smart Meter Testing:

My test setup consisted of a meter socket enclosure suitable for 120/240 Volt, single-phase, three-wire connection. A smart meter, Landis & Gyr, Gridstream RF, Focus AXR-SD, Form 2S, CL200, 240 V, 3 W, 60 Hz, power meter was used. The voltage waveform was captured with a Fluke 215C Scopemeter. One input to the Scopemeter was connected to the incoming voltage, 120 Volts-to-Ground, unfiltered. The other input to the Scopemeter was connected to the incoming voltage with the 60 Hz waveform filtered out. A radiofrequency emissions meter was also used to indicate when an RF signal increase was detected.[17]

When the test equipment was connected to the incoming power, the waveform of the incoming electrical power was observed. The 60 Hz signal was recognized as the dominant frequency with some noise observed on the waveform. The 60 Hz was filtered out to analyze the noise on the signal.[18]

When the smart meter was not connected, the noise level was approximately 45 milliVolts at its peak. When the smart meter was added to the circuit, the noise on the 60 Hz sine wave was noticeably larger, approximately 85 milliVolts. This is nearly double the amount of noise than without the smart meter.[19]

The dominant frequencies are in the range of 2 to 50 kHz. These are the frequencies that the smart meter generates when it is transmitting.[20]

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[17] Testimony of Erik S. Anderson, P.E. on behalf of Warren Woodward and in Opposition to the Settlement Agreement.
[18] ibid
[19] ibid
[20] ibid

The Landis + Gyr FOCUS AX and the GE (Alcara) I-210 + c SecureMesh DDV Electric Meters:

The Landis + Gyr Focus AX and the GE (Alcara) I-210 + c SecureMesh DDV Electric [smart] Meters used by CMP both incorporate a SMPS and RF communication. These electric smart meters create elevated RF signals.

Conclusion

The following opinions are based on my review of the materials, my examination of the operation of an electric smart meter, and my experience, education, and training. I hold these opinions to a reasonable degree of scientific certainty.

There is no doubt that smart and digital meters create pulsed RF emissions and these emissions, from the smart meters' antennas and the RF created by the SMPS, both enter the house's electric system. The result is that the entire house is transformed into a radiating RF antenna.

Any meter with a switch mode power supply will create RF frequencies in the Kilohertz range that enter the electrical wiring system of the house. Smart meters and digital meters inject significant levels of RF onto the home's electrical distribution system, polluting the otherwise relatively clean AC sine wave. These power quality or dirty electricity issues can cause significant and sometimes costly mechanical and electrical problems.[21]

Since all living things are beings of frequency, the strange thing would be if we were not in various ways also affected by man-made RF (like that from smart meters) we had not enough time to co-evolve with.

This report is based on information learned to date. I reserve the right to amend, clarify, or change my opinions based on more work or information learned.

Respectfully Submitted:

Erik S. Anderson, P.E.

[21] Kennedy, Barry. Power Quality Primer, McGraw-Hill 2000

Attachment 1.

1. Objections and Answers to Plaintiff's Interrogatories Propounded upon Defendant Central Maine Power Company.
2. CMP Power Quality Web Page. https://www.cmpco.com/wps/portal/cmp/home/!ut/p/z0/ZY3JDoIwFEV_RRcs9bWC09IYhRDRGIdgN6QglkptS60Dfy9ujNHdPcnJuUAgBiLpnTNquZJUNHwgg8TF0Szwpmg5irwxWnvuYuf7ezQfYwiBfAurTeg2gjfbBth3cTh8F3ommkYMiKa26HB5UhCbU9Yb4WG3sBfx2_g_aRr8XFVkAiRT0uZPC3F20ZSZ5HrTWhnroM_IZW5YLXhqqKkdVFB5TJUqHaTVIzet6kYFtzXokqR9wdov-0lUrQ!!/
3. Central Maine Power Company Response to Friedman Data Request No. 1.
4. Order on Defendant's Motion to Dismiss.
5. The Complaint.
6. Isotrope Wireless. Report on Examination of Selected Sources of Electromagnetic Fields at Selected Residences in Hastings-on-Hudson. November 23, 2013. http://stopsmartmetersny.org/images/Report_on_Examination_of_Selected_Sources_of_Electromagnetic_Fields_at_Selected_Residences_20140301.pdf
7. Sage Associates. Assessment of Radiofrequency Microwave Radiation Emissions from Smart Meters. January 1, 2011.
8. Expert Report of William Bathgate, McKnight v. PECO, C-2017-2621057. March 26, 2018.
9. Testimony of Erik S. Anderson, P.E. on behalf of Warren Woodward and in Opposition to the Settlement Agreement.
10. Kavanaugh, Jack. EMI Shielding Technology: The Industries It Touches and Why You Should Care. November 11, 2021. https://www.forbes.com/sites/forbestechcouncil/2021/11/11/emi-shielding-technology-the-industries-it-touches-and-why-you-should-care/?sh=462660b44365
11. https://smartmeterharm.org/2019/05/31/electrical-engineer-the-meter-itself-is-the-hazardous-condition/
12. Kennedy, Barry. Power Quality Primer, McGraw-Hill 2000 https://vdocuments.mx/power-quality-primer-barry-w-kennedy.html

Attachement 2.

ERIK S. ANDERSON

DATE	**COURT**	**CASE NUMBER**	**DEPO/TRIAL**
2021	In the Circuit Court of the Twelfth Judicial Circuit, Will County, Illinois	18 L 947	Deposition
2020	None	N/A	N/A
2019	In the Superior Court of the State of Arizona, In and for the County of Maricopa	CV 2017-012355	Trial
2018	In the Circuit Court of the State of Wisconsin In and for the County of Eau Claire	16-CV-31	Deposition
	In the Superior Court of the State of Arizona In and For the County of Maricopa	CV 2016-014713	Deposition (Orig.) Deposition (Supp.)
2017	In the Superior Court of the State of Arizona In and For the County of Maricopa	CV 2016-050257	Deposition
	In the Superior Court of the State of California, In and For the County Solano	No. FCS048117	Deposition
	Before the Arizona Corporation Commission	Docket # E-01345a-16-0036 Docket # E-01345a-16-0123	Admin. Hearing Testimony
	In the Superior Court of the State of Arizona, In and For the County of Maricopa	CV 2015-005133	Deposition

ANDERSON DEPOSITION EXHIBIT 3

UNITED STATES DISTRICT COURT
DISTRICT OF MAINE

ED FRIEDMAN	)	
	)	
	)	
Plaintiff,	)	
	)	**CIVIL ACTION**
v.	)	
	)	**Case NO. 20-cv-00237-JDL**
CENTRAL MAINE POWER COMPANY,	)	
	)	
	)	
Defendant.	)	

OBJECTIONS AND ANSWERS TO PLAINTIFF'S INTERROGATORIES PROPOUNDED UPON DEFENDANT CENTRAL MAINE POWER COMPANY

NOW COMES Defendant Central Maine Power (hereinafter "CMP") and responds to the Plaintiff's Interrogatories propounded upon it as follows.

RESERVATION OF RIGHTS WITH REGARD TO ANSWERS

1. The following responses represent the best information ascertained by Defendant CMP and is based upon information obtained from records and files within its possession, custody, or control. Defendant CMP reserves the right at any time to revise, correct, add to, or clarify any of the responses provided herein based upon newly discovered information.

2. The responses provided herein are subject to the right of Defendant CMP to object on any grounds, at any time, to a demand for further response to these or other interrogatories or other discovery procedures involving or relating to the subject matter of the interrogatories herein.

3. By responding to these interrogatories, Defendant CMP does not concede the relevancy or admissibility of the answers provided.

GENERAL OBJECTIONS

Although each of Plaintiff's interrogatories is addressed individually below, Defendant CMP makes the following general objections to interrogatories propounded by Plaintiff.

1. Defendant CMP objects generally to Plaintiff's "Instructions" to the extent that they seek to expand Defendant CMP's discovery obligations beyond those imposed by the Federal Rules of Civil Procedure ("Federal Rules").

2. Defendant CMP objects to the attempt by Plaintiff to impose any duty on Defendant CMP regarding supplemental answers that is not required by the Federal Rules of Civil Procedure. Defendant CMP will respond to the interrogatories in the manner required by the Federal Rules.

3. Defendant CMP objects to all interrogatories to the extent that they seek information protected by the attorney-client privilege or by the work-product/trial preparation materials immunity including, but not limited to, communications between Defendant CMP and its attorneys.

4. Defendant CMP objects to all interrogatories to the extent they seek information or material protected by statutory privilege, the physician-patient privilege, the Maine Health Security Act, or any other applicable privilege or doctrine.

5. Defendant CMP objects to all interrogatories to the extent they seek information or documents which are confidential including, but not limited to, confidential information and documents in, or relating to, personnel files of current and former employees, trade secrets and sensitive business information.

6. Each of the foregoing general objections is incorporated into each of the individual responses below.

RESPONSES TO INTERROGATORIES

Subject to the foregoing general objections, and without in any way waiving or limiting the generality of the same, Defendant CMP responds to Plaintiff's specific interrogatories as follows:

INTERROGATORY NO. 1

Identify the number of CMP customers who have requested a smart meter opt-out.

RESPONSE:

Pursuant to Fed. R. Civ. P. 33(d), please refer to the attached document entitled "AMI Opt Out Customers and Number of Times On-Going Support Costs Charged."

INTERROGATORY NO. 2

Identify the number of CMP customers who have requested a waiver of the smart meter opt-out fee.

RESPONSE:

CMP does not have a waiver process for the opt-out fees and CMP has not tracked customers who have expressed not wanting to pay the opt-out fees.

INTERROGATORY NO. 3

Identify the number of CMP customers who have requested an opt-out or waiver of the smart meter opt-out fee due to a claimed disability or health issue.

RESPONSE:

CMP is aware of three customers, including the Plaintiff, who have expressed concerns about both the health effects of smart meters and the requirement that they pay an opt-out fee.

INTERROGATORY NO. 4

Identify all persons for whom CMP has waived or forgiven smart meter opt-out fees.

OBJECTION:

The Defendant objects to the request that it identify by name customers whose opt-out fees have been forgiven, on the ground that to do so would be unduly burdensome, not relevant to a claim or defense, and not reasonably calculated to lead to the discovery of admissible evidence.

RESPONSE:

CMP has waived the payment of opt out fees in a number of circumstances including:

- If a customer indicated that he/she was confused when selecting an opt-out option on their opt-out mailing return card, the Company would waive the opt out-arrears on their account
- If requested by the Consumer Assistance Safety Division ("CASD") of the Maine Public Utilities Commission ("MPUC") as in the case CASD No. 2011-32054 - Central Maine Power Company.
- In the situation where the opt-out customer on record is deceased and the surviving spouse has called to take over service.
- The Company did not charge the $25.00 surcharge to those opt-out customers who responded to the mailing after 30 days.
- As is specified in the terms and conditions section 12.11, an opt out fee would be modified in the following case:

> If the customer participates in the Company's Residential Electricity Lifeline Program described in CMP's Term and Condition 33 and has an income level equal to or less than 100% of the Federal Poverty Guidelines, the customer will pay fifty percent (50%) of the Initial Charge and Recurring Monthly Charge related to their opt-out selection. If the customer participates in the Company's Residential Electricity Lifeline Program and has an income level greater than 100% of the Federal Poverty Guidelines, the customer will pay seventy-five percent (75%) of the Initial Charge and Recurring Monthly Charge related to their opt-out selection.

INTERROGATORY NO. 5

Identify "CMP's obligations under state law" described in CMP's Fifth Affirmative Defense.

RESPONSE:

Title 35-A, Section 304, of the Maine Revised Statutes provides:

> Every public utility shall file with the commission, within a time to be fixed by the commission, schedules which shall be open to public inspection. The schedules shall show all rates, tolls and charges which the utility has established and which are in force at the time for any service performed by it within the State, or for any service in connection with or performed by any public utility controlled or operated by it or in conjunction with it. Every public utility shall file with and as part of its schedules all terms and conditions that in any manner affect the rates charged or to be charged for any service.
>
> Public utility schedules which were formerly designated as rules shall be designated as terms and conditions. All such schedules to be filed with the commission shall be designated as terms and conditions.

Title 35-A, Section 703(1), of the Maine Revised Statutes provides (subject to exceptions not relevant here):

> No person may knowingly solicit, accept or receive any rebate, discount or discrimination in respect to any service rendered, or to be rendered by a public utility, or for any related service where the service is rendered free or at a rate less than named in the schedules in force, or where a service or advantage is received other than is specified.

These laws require CMP to charge Mr. Friedman the same opt-out fee it charges to each of its opt-out customers.

Additionally, the MPUC's May 19, 2011 (Part I) Order in Docket 2010-345:

- Required CMP to allow any customer for any reason to opt out of receiving CMP's standard smart meter;
- Required CMP to charge specified opt-out fees; and
- Required CMP to file Terms & Conditions (T&Cs) that incorporate the MPUC's required opt-out fees. In response to the MPUC Order CMP adopted opt-out fees set forth in Section 12.11 of CMP's T&Cs, which were approved by the MPUC.

The MPUC's June 22, 2011 (Part II) Order in Docket 2010-345 explained that in arriving at its decision to require CMP to charge opt-out fees, the Commission had rejected the argument that "the incremental costs of providing the opt-out alternatives should not be charged directly to the opt-out customers, but paid for by all of CMP's ratepayers." The MPUC further stated: "As a general utility ratemaking principle, customers that request non-standard services should pay the incremental costs of those services. In our view, it would be inconsistent with ratemaking principles and basically inequitable for CMP to recover the costs caused by an individual customer's decision to opt-out of receiving a standard wireless meter from its general body of ratepayers."

INTERROGATORY NO. 6

Describe how "[w]aiving the opt-out fee for individual customers" would "fundamentally alter the nature of the services CMP provides to Maine consumers as a public utility." See R. Doc. 31, pg. 2.

RESPONSE:

It is a general ratemaking principle that customers who request non-standard services should pay the incremental cost of those services. The Maine Public Utilities Commission (MPUC) adhered to that principle when it issued its Order requiring that customers who opt out of the smart meter program bear the cost of non-standard metering. The MPUC reasoned that it would be "inequitable for CMP to recover the costs caused by an individual customer's decision to opt out of receiving a standard wireless meter from its general body of ratepayers." PUC Op-Out Order Part II, at 14.

INTERROGATORY NO. 7

Describe the "legitimate business reasons" identified in your Tenth Affirmative Defense.

RESPONSE:

Please refer to the Answers to Interrogatories Nos. 5 and 6. It is a legitimate business practice for CMP to adhere to the general utility principle – adopted by the MPUC – that customers who request non-standard services should pay the incremental costs of those services, in order to avoid shifting costs to those who are not responsible for the costs.

INTERROGATORY NO. 8

Identify all facts forming the basis for your Twelfth Affirmative Defense, that "Plaintiff's claims are barred by the applicable statutes of limitations."

RESPONSE:

The MPUC ordered CMP to charge opt-out fees as of October 1, 2011.

The Plaintiff alleges that he declined to have a smart meter installed at his residence.

Electrical service to the Plaintiff's home was disconnected on or about August 25, 2016.

This action was commenced on July 7, 2020.

INTERROGATORY NO. 9

Describe the typical or average radiofrequency output of your smart meters, including in terms of frequency, wattage, and number of transmissions per hour.

OBJECTION:

CMP objects to this interrogatory insofar as it purports to impose upon CMP an obligation to compute an average number of transmissions per hour for all of its smart meters.

RESPONSE:

The average frequency of CMP smart meters is 2.45 gigahertz (GHz).

The average wattage used by CMP smart meters is 1 Watt.

The number of transmissions per hour varies among smart meters, depending on the number of descendants any meter has. As of 2012, according to the *Measurement Validation of Exposure Predictions from the Central Maine Power Smart Meter Network*, prepared by Exponent and dated September 19, 2012:

- The typical CMP smart meter was off for more than 99.998% of the time.
- A smart meter with no descendants would produce an RF signal for approximately 0.145

seconds per day.

- A smart meter with six descendants would produce an RF signal for approximately 0.869 seconds per day.

- A smart meter with 60 descendants would produce an RF signal for approximately 8.7 seconds per day.

DATED: 9/7/2021

CENTRAL MAINE POWER COMPANY

By: ______________________

Its: General Counsel and Secretary

STATE OF MAINE
CUMBERLAND, SS.

September 7, 2021

Personally appeared before me the above-named Carlisle Tuggey and made oath that the foregoing statements above represent the information available to Central Maine Power Company.

KATHRYN VAZNIS
Notary Public-Maine
My Commission Expires
September 29, 2023

Kathryn Vaznis
Notary Public

My Commission Expires 9/29/2023

AS TO OBJECTIONS:

NORMAN, HANSON & DeTROY, LLC

DATED: 9/7/21

____
Christopher C. Taintor, Esq.
Attorney for Defendant

Norman, Hanson & DeTroy
Two Canal Plaza, P.O. Box 4600
Portland, ME 04112-4600
(207) 774-7000

CERTIFICATE OF SERVICE

I hereby certify that on September 7, 2021, a copy of *OBJECTIONS AND ANSWERS TO PLAINTIFF'S INTERROGATORIES PROPOUNDED UPON DEFENDANT CENTRAL MAINE POWER COMPANY* was transmitted to counsel for Plaintiffs by email.

/s/Christopher C. Taintor
Christopher C. Taintor

ANDERSON DEPOSITION EXHIBIT 4

SAGE
Associates
ENVIRONMENTAL CONSULTANTS

Assessment of Radiofrequency Microwave Radiation Emissions from Smart Meters

Sage Associates
Santa Barbara, CA
USA

January 1, 2011

TABLE OF CONTENTS

SUMMARY OF FINDINGS

This Report has been prepared to document radiofrequency radiation (RF) levels associated with wireless smart meters in various scenarios depicting common ways in which they are installed and operated.

The Report includes computer modeling of the range of possible smart meter RF levels that are occurring in the typical installation and operation of a single smart meter, and also multiple meters in California. It includes analysis of both two-antenna smart meters (the typical installation) and of three-antenna meters (the collector meters that relay RF signals from another 500 to 5000 homes in the area).

RF levels from the various scenarios depicting normal installation and operation, and possible FCC violations have been determined based on both time-averaged and peak power limits (Tables 1 - 14).

Potential violations of current FCC public safety standards for smart meters and/or collector meters in the manner installed and operated in California are predicted in this Report, based on computer modeling (Tables 10 – 17).

Tables 1 – 17 show power density data and possible conditions of violation of the FCC public safety limits, and Tables 18 – 33 show comparisons to health studies reporting adverse health impacts.

FCC compliance violations are likely to occur under normal conditions of installation and operation of smart meters and collector meters in California. Violations of FCC safety limits for uncontrolled public access are identified at distances within 6” of the meter. Exposure to the face is possible at this

distance, in violation of the time-weighted average safety limits (Tables 10-11). FCC violations are predicted to occur at 60% reflection (OET Equation 10 and 100% reflection (OET Equation 6) factors*, both used in FCC OET 65 formulas for such calculations for time-weighted average limits. Peak power limits are not violated at the 6" distance (looking at the meter) but can be at 3" from the meter, if it is touched.

This report has also assessed the potential for FCC violations based on two examples of RF exposures in a typical residence. RF levels have been calculated at distances of 11" (to represent a nursery or bedroom with a crib or bed against a wall opposite one or more meters); and at 28" (to represent a kitchen work space with one or more meters installed on the kitchen wall).

FCC compliance violations are identified at 11" in a nursery or bedroom setting using Equation 10* of the FCC OET 65 regulations (Tables 12-13). These violations are predicted to occur where there are multiple smart meters, or one collector meter, or one collector meter mounted together with several smart meters.

FCC compliance violations are not predicted at 28" in the kitchen work space for 60% or for 100% reflection calculations. Violations of FCC public safety limits are predicted for higher reflection factors of 1000% and 2000%, which are not a part of FCC OET 65 formulas, but are included here to allow for situations where site-specific conditions (highly reflective environments, for example, galley-type kitchens with many highly reflective stainless steel or other metallic surfaces) may be warranted.*

*FCC OET 65 Equation 10 assumes 60% reflection and Equation 6 assumes 100% reflection. RF levels are also calculated in this report to account for some situations where interior environments have highly reflective surfaces as might be found in a small kitchen with stainless steel or other metal counters, appliances and furnishings. This report includes the FCC's reflection factors of 60% and 100%, and also reflection factors of1000% and 2000% that are more in line with those reported in Hondou, 2001; Hondou, 2006 and Vermeeren et al, 2010. The use of a 1000% reflection factor is still conservative in comparison to Hondou, 2006. A 1000% reflection factor is 12% (or 121 times as high) a factor for power density compared to Hondou et al, 2006 prediction of 1000 times higher power densities due to reflection. A 2000% reflection factor is only 22% (or 441 times) that of Hondou's finding that power density can be as high as 2000 times higher.

In addition to exceeding FCC public safety limits under some conditions of installation and operation, smart meters can produce excessively elevated RF exposures, depending on where they are installed. With respect to absolute RF exposure levels predicted for occupied space within dwellings, or outside areas like patios, gardens and walk-ways, RF levels are predicted to be substantially elevated within a few feet to within a few tens of feet from the meter(s).

For example, one smart meter at 11" from occupied space produces somewhere between 1.4 and 140 microwatts per centimeter squared (uW/cm2) depending on the duty cycle modeled (Table 12). Since FCC OET 65 specifies that continuous exposure be assumed where the public cannot be excluded (such as is applicable to one's home), this calculation produces an RF level of 140 uW/cm2 at 11" using the FCCs lowest reflection factor of 60%. Using the FCC's reflection factor of 100%, the figures rise to 2.2 uW/cm2 – 218 uW/cm2, where the continuous exposure calculation is 218 uW/cm2 (Table 12). These are very significantly elevated RF exposures in comparison to typical individual exposures in daily life. Multiple smart meters in the nursery/bedroom example at 11" are predicted to generate RF levels from about 5 to 481 uW/cm2 at the lowest (60%) reflection factor; and 7.5 to 751 uW/cm2 using the FCCs 100% reflection factor (Table 13). Such levels are far above typical public exposures.

RF levels at 28" in the kitchen work space are also predicted to be significantly elevated with one or more smart meters (or a collector meter alone or in combination with multiple smart meters). At 28" distance, RF levels are predicted in the kitchen example to be as high as 21 uW/cm2 from a single meter and as high as 54.5 uW/cm2 with multiple smart meters using

the lower of the FCCs reflection factor of 60% (Table 14). Using the FCCs higher reflection factor of 100%, the RF levels are predicted to be as high as 33.8 uW/cm2 for a single meter and as high as 85.8 uW/cm2 for multiple smart meters (Table 14). For a single collector meter, the range is 60.9 to 95.2 uW/cm2 (at 60% and 100% reflection factors, respectively) (from Table 15).

Table 16 illustrates predicted violations of peak power limit (4000 uW/cm2) at 3" from the surface of a meter. FCC violations of peak power limit are predicted to occur for a single collector meter at both 60% and 100% reflection factors. This situation might occur if someone touches a smart meter or stands directly in front.

Consumers may also have already increased their exposures to radiofrequency radiation in the home through the voluntary use of wireless devices (cell and cordless phones), PDAs like BlackBerry and iPhones, wireless routers for wireless internet access, wireless home security systems, wireless baby surveillance (baby monitors), and other emerging wireless applications.

Neither the FCC, the CPUC, the utility nor the consumer know what portion of the allowable public safety limit is already being used up or pre-empted by RF from other sources already present in the particular location a smart meter may be installed and operated.

Consumers, for whatever personal reason, choice or necessity who have already eliminated all possible wireless exposures from their property and lives, may now face excessively high RF exposures in their homes from

smart meters on a 24-hour basis. This may force limitations on use of their otherwise occupied space, depending on how the meter is located, building materials in the structure, and how it is furnished.

People who are afforded special protection under the federal Americans with Disabilities Act are not sufficiently acknowledged nor protected. People who have medical and/or metal implants or other conditions rendering them vulnerable to health risks at lower levels than FCC RF limits may be particularly at risk (Tables 30-31). This is also likely to hold true for other subgroups, like children and people who are ill or taking medications, or are elderly, for they have different reactions to pulsed RF. Childrens' tissues absorb RF differently and can absorb more RF than adults (Christ et al, 2010; Wiart et al, 2008). The elderly and those on some medications respond more acutely to some RF exposures.

Safety standards for peak exposure limits to radiofrequency have not been developed to take into account the particular sensitivity of the eyes, testes and other ball shaped organs. There are no peak power limits defined for the eyes and testes, and it is not unreasonable to imagine situations where either of these organs comes into close contact with smart meters and/or collector meters, particularly where they are installed in multiples (on walls of multi-family dwellings that are accessible as common areas).

In summary, no positive assertion of safety can be made by the FCC, nor relied upon by the CPUC, with respect to pulsed RF when exposures are chronic and occur in the general population. Indiscriminate exposure to environmentally ubiquitous pulsed RF from the rollout of millions of new RF sources (smart meters) will mean far greater general population exposures, and potential health consequences. Uncertainties about the

existing RF environment (how much RF exposure already exists), what kind of interior reflective environments exist (reflection factor), how interior space is utilized near walls), and other characteristics of residents (age, medical condition, medical implants, relative health, reliance on critical care equipment that may be subject to electronic interference, etc) and unrestrained access to areas of property where meter is located all argue for caution.

INTRODUCTION

How Smart Meters Work

This report is limited to a very simple overview of how smart meters work, and the other parts of the communication system that are required for them to transmit information on energy usage within a home or other building. The reader can find more detailed information on smart meter and smart grid technology from numerous sources available on the Internet.

Often called 'advanced metering infrastructure or AMI', smart meters are a part of an overall system that includes a) a mesh network or series of wireless antennas at the neighborhood level to collect and transmit wireless information from all the smart meters in that area back to a utility.

The mesh network (sometimes called a distributed antenna system) requires wireless antennas to be located throughout neighborhoods in close proximity to where smart meters will be placed. Often, a municipality will receive a hundred or more individual applications for new cellular antenna service, which is specifically to serve smart meter technology needs. The communication network needed to serve smart meters is typically separate from existing cellular and data transmission antennas (cell tower antennas). The mesh network (or DAS) antennas are often utility-pole mounted. This part of the system can spread hundreds of new wireless antennas throughout neighborhoods.

Smart meters are a new type electrical meter that will measure your energy usage, like the old ones do now. But, it will send the information back to the utility by wireless signal (radiofrequency/microwave radiation signal) instead of having a utility meter reader come to the property and manually

do the monthly electric service reading. So, smart meters are replacements for the older 'spinning dial' or analog electric meters. Smart meters are not optional, and utilities are installing them even where occupants do not want them.

In order for smart meters to monitor and control energy usage via this wireless communication system, the consumer must be willing to install power transmitters inside the home. This is the third part of the system and involves placing power transmitters (radiofrequency/microwave radiation emitting devices) within the home on each appliance. A power transmitter is required to measure the energy use of individual appliances (e.g., washing machines, clothes dryers, dishwashers, etc) and it will send information via wireless radiofrequency signal back to the smart meter. Each power transmitter handles a separate appliance. A typical kitchen and laundry may have a dozen power transmitters in total. If power transmitters are not installed by the homeowner, or otherwise mandated on consumers via federal legislation requiring all new appliances to have power transmitters built into them, then there may be little or no energy reporting nor energy savings.

Smart meters could also be installed that would operate by wired, rather than wireless means. Shielded cable, such as is available for cable modem (wired internet connection) could connect smart meters to utilities. However, it is not easy to see the solution to transmit signals from power transmitters (energy use for each appliance) back to the utility.

Collector meters are a special type of smart meter that can serve to collect the radiofrequency/microwave radiation signals from many surrounding

buildings and send them back to the utility. Collector meters are intended to collect and re-transmit radiofrequency information for somewhere between 500-5000 homes or buildings. They have three operating antennas compared to two antennas in regular smart meters. Their radiofrequency microwave emissions are higher and they send wireless signal much more frequently. Collector meters can be place on a home or other building like smart meters, and there is presently no way to know which a homeowner or property owner might receive.

Mandate

The California Public Utilities Commission has authorized California's investor-owned utilities (including Pacific Gas & Electric, Southern California Edison Company and San Diego Gas & Electric) to install more than 10 million new wireless* smart meters in California, replacing existing electric meters as part of the federal SmartGrid program.

The goal is to provide a new residential energy management tool. It is intended to reduce energy consumption by providing computerized information to customers about what their energy usage is and how they might reduce it by running appliances during 'off-time' or 'lower load' conditions. Presumably this will save utilities from having to build new facilities for peak load demand. Utilities will install a new smart meter on every building to which electrical service is provided now. In Southern California, that is about 5 million smart meters in three years for a cost of around $1.6 billion dollars. In northern California, Pacific Gas & Electric is slated to install millions of meters at a cost of more than $2.2 billion dollars. If consumers decide to join the program (so that appliances can report

energy usage to the utility), they can be informed about using energy during off-use or low-use periods, but only if consumers also agree to install additional wireless power transmitters on appliances inside the home. Each power transmitter is an additional source of pulsed RF that produces high exposures at close range in occupied space within the home.

> *"Proponents of smart meters say that when these meters are teamed up with an in-home display that shows current energy usage, as well as a communicating thermostat and software that harvest and analyze that information, consumers can see how much consumption drives cost -- and will consume less as a result. Utilities are spending billions of dollars outfitting homes and businesses with the devices, which wirelessly send information about electricity use to utility billing departments and could help consumers control energy use."*
>
> Wall Street Journal, April 29, 2009.

The smart meter program is also a tool for load-shedding during heavy electrical use periods by turning utility meters off remotely, and for reducing the need for utility employees to read meter data in the field.

Purpose of this Report

This Report has been prepared to document radiofrequency radiation (RF) levels associated with wireless smart meters in various scenarios depicting common ways in which they are installed and operated.

The Report includes computer modeling of the range of possible smart meter RF levels that are occurring in the typical installation and operation of a single smart meter, and also multiple meters in California. It includes analysis of both two-antenna smart meters (the typical installation) and of

three-antenna meters (the collector meters that relay RF signals from another 500 to 5000 homes in the area).

RF levels from the various scenarios depicting normal installation and operation, and possible FCC violations have been determined based on both time-averaged and peak power limits (Tables 1 - 14).

Potential violations of current FCC public safety standards for smart meters and/or collector meters in the manner installed and operated in California are illustrated in this Report, based on computer modeling (Tables 10 – 17).

Tables which present data, possible conditions of violation of the FCC public safety limits, and comparisons to health studies reporting adverse health impacts are summarized (Tables 18 – 33).

The next section describes methodology in detail, but generally this Report provides computer modeling results for RF power density levels for these scenarios, analysis of whether and under what conditions FCC public safety limit violations may occur, and comparison of RF levels produced under these scenarios to studies reporting adverse health impacts with chronic exposure to low-intensity radiofrequency radiation at or below levels produced by smart meters and collector meters in the manner installed and operated in California.

1) Single ‘typical’ meter - tables showing RF power density at increasing distances in 0.25’ (3”) intervals outward for single meter (two-antenna meter). Effects of variable duty cycles (from 1% to 90%) and various reflection factors (60%, 100%, 1000% and 2000%) have been calculated.
2) Multiple ‘typical’ meters - tables showing RF power density at increasing distances as above.

3) Collector meter - tables showing RF power density related to a specialized collector meter which has three internal antennas (one for every 500 or 5000 homes) as above.
4) Collector meter - a single collector meter installed with multiple 'typical' two-antenna meters as above.
5) Tables are given to illustrate the distance to possible FCC violations for time-weighted average and peak power limits (in inches).
6) Tables are given to document RF power density levels at various key distances (11" to a crib in a bedroom; 28" to a kitchen work area; and 6" for a person attempting to read the digital readout of a smart meter, or inadvertently working around a meter.
7) Tables are given to compare RF power density levels with studies reporting adverse health symptoms and effects (and those levels of RF associated with such health effects).
8) Tables are given to compare smart meter and collector meter RF to BioInitiative Report recommended limit (in feet).

Framing Questions

In view of the rapid deployment of smart meters around the country, and the relative lack of public information on their radiofrequency (RF) emission profiles and public exposures, there is a crucial need to provide independent technical information.

There is very little solid information on which decision-makers and the public can make informed decisions about whether they are an acceptable new RF exposure, in combination with pre-existing RF exposures.

On-going Assessment of Radiofrequency Radiation Health Risks

The US NIEHS National Toxicology Program nominated radiofrequency radiation for study as a carcinogen in 1999. Existing safety limits for pulsed RF were termed "not protective of public health" by the

Radiofrequency Interagency Working Group (a federal interagency working group including the FDA, FCC, OSHA, the EPA and others). Recently, the NTP issued a statement indicating it will complete its review by 2014 (National Toxicology Program, 2009). The NTP radiofrequency radiation study results have been delayed for more than a decade since 1999 and very little laboratory or epidemiological work has been completed. Thus, he explosion of wireless technologies is producing radiofrequency radiation exposures over massive populations before questions are answered by federal studies about the carcinogenicity or toxicity of low-intensity RF such as are produced by smart meters and other SmartGrid applications of wireless. The World Health Organization and the International Agency for Research on Cancer have not completed their studies of RF (the IARC WHO RF Health Monograph is not expected until at least 2011). In the United States, the National Toxicology Program listed RF as a potential carcinogen for study, and has not released any study results or findings a decade later. There are no current, relevant public safety standards for pulsed RF involving chronic exposure of the public, nor of sensitive populations, nor of people with metal and medical implants that can be affected both by localized heating and by electromagnetic interference (EMI) for medical wireless implanted devices.

Considering that millions of smart meters are slated to be installed on virtually every electrified building in America, the scope of the question is large and highly personal. Every family home in the country, and every school classroom – every building with an electric meter – is to have a new wireless meter – and thus subject to unpredictable levels of RF every day.

1) Have smart meters been tested and shown to comply with FCC

public safety limits (limits for uncontrolled public access)?

2) Are these FCC public safety limits sufficiently protective of public health and safety? This question is posed in light of the last thirty years of international scientific investigation and public health assessments documenting the existence of bioeffects and adverse health effects at RF levels far below current FCC standards. The FCC's standards have not been updated since 1992, and did not anticipate nor protect against chronic exposures (as opposed to acute exposures) from low-intensity or non-thermal RF exposures, particularly pulsed RF exposures.

3) What demonstration is there that wireless smart meters will comply with existing FCC limits, as opposed to under strictly controlled conditions within government testing laboratories?

4) Has the FCC been able to certify that compliance is achievable under real-life use conditions including, but not limited to:

- In the case where there are both gas and electric meters on the home located closely together.

- In the case where there is a "bank" of electric and gas meters, on a multi-family residential building such as on a condominium or apartment building wall. There are instances of up to 20 or more meters located in close proximity to occupied living space in the home,in the classroom or other occupied public space.

• In the case where there is a collector meter on a home that serves the home plus another 500 to 5000 other residential units in the area, vastly increasing the frequency of RF bursts.

• In the case where there is one smart meter on the home but it acts as a relay for other local neighborhood meters. What about 'piggybacking' of other neighbors' meters through yours? How can piggybacking be reasonably estimated and added onto the above estimates?

• What about the RF emissions from the power transmitters? Power transmitters installed on appliances (perhaps 10-15 of them per home) and each one is a radiofrequency radiation transmitter.

• How can the FCC certify a system that has an unknown number of such transmitters per home, with no information on where they are placed?

• Where people with medical/metal implants are present? (Americans with Disabilities Act protects rights)

5) What assessment has been done to determine what pre-existing conditions of RF exposure are already present. On what basis can compliance for the family inside the residence be assured, when there is no verification of what other RF sources exist on private property? How is the problem of cumulative RF exposure properly assessed (wireless routers, wireless laptops, cell phones, PDAs, DECT or other active-base cordless phone systems, home security systems,

baby monitors, contribution of AM, FM, television, nearby cell towers, etc).

6) What is the cumulative RF emissions worst-case profile? Is this estimate in compliance?

7) What study has been done for people with metal implants* who require protection under Americans with Disabilities Act? What is known about how metal implants can intensity RF, heat tissue and result in adverse effects below RF levels allowed for the general public. What is known about electromagnetic interference (EMI) from spurious RF sources in the environment (RFID scanners, cell towers, security gates, wireless security systems, wireless communication devices and routers, wireless smart meters, etc)

*Note: There are more than 20 million people in the US who need special protection against such exposures that may endanger them. High peak power bursts of RF may disable electronics in some critical care and medical implants. We already have reports of wireless devices disabling deep brain stimulators in Parkinson's patients and there is published literature on malfunctions with critical care equipment.

PUBLIC SAFETY LIMITS FOR RADIOFREQUENCY RADIATION

The FCC adopted limits for Maximum Permissible Exposure (MPE) are generally based on recommended exposure guidelines published by the National Council on Radiation Protection and Measurements (NCRP) in "Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields," (NCRP, 1986).

In the United States, the Federal Communications Commission (FCC) enforces limits for both occupational exposures (in the workplace) and for public exposures. The allowable limits are variable, according to the frequency transmitted. Only public safety limits for uncontrolled public access are assessed in this report.

Maximum permissible exposures (MPE) to radiofrequency electromagnetic fields are usually expressed in terms of the plane wave equivalent power density expressed in units of milliwatts per square centimeter (mW/cm2) or alternatively, absorption of RF energy is a function of frequency (as well as body size and other factors). The limits vary with frequency. Standards are more restrictive for frequencies at and below 300 MHz. Higher intensity RF exposures are allowed for frequencies between 300 MHz and 6000 MHz than for those below 300 MHz.

In the frequency range from 100 MHz to 1500 MHz, exposure limits for field strength and power density are also generally based on the MPE limits found in Section 4.1 of "*IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz*," ANSI/IEEE C95.1-1992 (IEEE, 1992, and approved for use as an American National Standard by the American National Standards Institute

(ANSI).

US Federal Communications Commission (FCC) Exposure Standards

Table 1, Appendix A FCC LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)

(A) Limits for Occupational/Controlled Exposure

Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (H) (A/m)	Power Density (S) (mW/cm2)	Averaging Time $[E]^2$ $[H]^2$ or S (minutes)
0.3-3.0	614	1.63	(100)*	6
3.0-30	1842/f	4.89/f	$(900/f_2)$*	6
30-300	61.4	0.163	1.0	6
300-1500			f/300	6
1500-100,000			5	6

B) FCC Limits for General Population/Uncontrolled Exposure

Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (H) (A/m)	Power Density (S) (mW/cm2)	Averaging Time $[E]^2$ $[H]^2$ or S (minutes)
0.3-3.0	614	1.63	(100)*	30
3.0-30	824/f	2.19/f	$(180/f_2)$*	30
30-300	27.5	0.073	0.2	30
300-1500	--	--	f/1500	30
1500-100,000	--	--	1.0	30

f = frequency in MHz *Plane-wave equivalent power density

NOTE 1: ***Occupational/controlled*** limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.

NOTE 2: ***General population/uncontrolled*** exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or can not exercise control over their exposure. Source: FCC Bulletin OET 65 Guidelines, page 67 OET, 1997.

In this report, the public safety limit for a smart meter is a combination of the individual antenna frequency limits and how much power output they create. A smart meter contains two antennas. One transmits at 915 MHz and the other at 2405 MHz. They can transmit at the same time, and so their effective radiated power is summed in the calculations of RF power density. Their combined limit is 655 uW/cm2. This limit is calculated by formulas from Table 1, Part B and is proportionate to the power output and specific safety limit (in MHz) of each antenna.

For the collector meter, with it's three internal antennas, the combined public safety limit for time-averaged exposure is 571 MHz (a more restrictive level since it includes an additional 824 MHz antenna that has a lower limit than either the 915 MHz or the 2405 MHz antennas). In a collector meter, only two of the three antennas can transmit simultaneously (the 915 MHz LAN and the GSM 850 MHz (from the FCC Certification Exhibit titled RF Exposure Report for FCC ID: SK9AMI-2A). The proportionate power output of each antenna plus the safety limit for each antenna frequency combines to give a safety limit for the collector meter of 571 uW/cm2. Where one collector meter is combined with multiple smart meters, the combined limit is weighted upward by the additional smart meters' contribution, and is 624 uW/cm2.

Continuous Exposure

FCC Bulletin OET 65 guidelines require the assumption of continuous exposure in calculations. Duty cycles offered by the utilities are a fraction of continuous use, and significantly diminish predictions of RF exposure.

At present, there is no evidence to prove that smart meters are functionally unable to operate at higher duty cycles that some utilities have estimated (estimates vary from 1% to 12.5% duty cycle, and as high as 30%). Confirming this is the Electric Power Research Institute (EPRI) in its "Perspective on Radio-Frequency Exposure Associated with Residential Automatic Meter Reading Technology (EPRI, 2010) According to EPRI:

> *"The technology not only provides a highly efficient method for obtaining usage data from customers, but it also can provide up-to-the-minute information on consumption patterns since the meter reading devices can be programmed to provide data as often as needed."* Emphasis added

The FCC Bulletin OET 65 guidelines specify that continuous exposure (defined by the FCC OET 65 as 100% duty cycle) is required in calculations where it is not possible to control exposures to the general public.

> *"It is important to note that for general population/uncontrolled exposures it is often not possible to control exposures to the extent that averaging times can be applied. In those situations, it is often necessary to assume continuous exposure."* (emphasis added)
> FCC Bulletin OET 65, p, 10

> ***"Duty factor**. The ratio of pulse duration to the pulse period of a periodic pulse train. Also, may be a measure of the temporal transmission characteristic of an intermittently transmitting RF source such as a paging antenna by dividing average transmission duration by the average period for transmissions. A duty factor of 1.0 corresponds to continuous operation."*
> (emphasis added)
> FCC Bulletin OET 65, p, 2

This provision then specifies duty cycles to be increased to 100%.

The FCC Guidelines (OET 65) further address cautions that should be observed for uncontrolled public access to areas that may cause exposure to high levels of RF.

Re-radiation

> *The foregoing also applies to high RF levels created in whole or in part by re-eradiation. A convenient rule to apply to all situations involving RF radiation is the following:*
>
> *(1) Do not create high RF levels where people are or could reasonably be expected to be present, and (2) [p]revent people from entering areas in which high RF levels are necessarily present.*
>
> *(2) Fencing and warning signs may be sufficient in many cases to protect the general public. Unusual circumstances, the presence of multiple sources of radiation, and operational needs will require more elaborate measures.*
>
> *(3) Intermittent reductions in power, increased antenna heights, modified antenna radiation patterns, site changes, or some combination of these may be necessary, depending on the particular situation.*
>
> FCC OET 65, Appendix B, p. 79

Fencing, distancing, protective RF shielded clothing and signage warning occupants not to use portions of their homes or properties are not feasible nor desirable in public places the general public will spend time (schools, libraries, cafes, medical offices and clinics, etc) These mitigation strategies may be workable for RF workers, but are unsuited and intolerable for the public.

Reflections

A major, uncontrolled variable in predicting RF exposures is the degree to

which a particular location (kitchen, bedroom, etc) will reflect RF energy created by installation of one or more smart meters, or a collector meter and multiple smart meters. The reflectivity of a surface is a measure of the amount of reflected radiation. It can be defined as the ratio of the intensities of the reflected and incident radiation. The reflectivity depends on the angle of incidence, the polarization of the radiation, and the electromagnetic properties of the materials forming the boundary surface. These properties usually change with the wavelength of the radiation. The reflectivity of polished metal surfaces is usually quite high (such as stainless steel and polished metal surfaces typical in kitchens, for example).

Reflections can significantly increase localized RF levels. High uncertainty exists about how extensive a problem this may create in routine installations of smart meters, where the utility and installers have no idea what kind of reflectivity is present within the interior of buildings.

Reflections in Equation 6 and 10 of the FCC OET Bulletin 65 include rather minimal reflection factors of 100% and 60%, respectively. This report includes higher reflection factors in line with published studies by Hondou et al, 2006, Hondou, 2002 and Vermeeren et al, 2010. Reflection factors are modeled at 1000% and 2000% as well as at 60% and 100%, based on published scientific evidence for highly reflective environments. Hondou (2002) establishes that power density can be higher than conventional formulas predict using standard 60% and 100% reflection factors.

> *"We show that this level can reach the reference level (ICNIRP Guideline) in daily life. This is caused by the fundamental properties of electromagnetic field, namely, reflection and additivity. The level of exposure is found to be much higher than estimated by conventional framework of analysis that assumes that the level*

rapidly decreases with the inverse square distance between the source and the affected person."

"Since the increase of electromagnetic field by reflective boundaries and the additivity of sources has not been recognized yet, further detailed studies on various situations and the development of appropriate regulations are required."

Hondou et al (2006) establishes that power densities 1000 times to 2000 times higher than the power density predictions from computer modeling (that does not account properly for reflections) can be found in daily living situations. Power density may not fall off with distance as predicted by formulas using limited reflection factors. The RF hot spots created by reflection can significantly increase RF exposures to the public, even above current public safety limits.

"We confirm the significance of microwave reflection reported in our previous Letter by experimental and numerical studies. Furthermore, we show that 'hot spots' often emerge in reflective areas, where the local exposure level is much higher than average."

"Our results indicate the risk of 'passive exposure' to microwaves."

"The experimental values of intensity are consistently higher than predicted values. Intensity does not even decrease with distance from the source."

"We further confirm the existence of microwave 'hotspots', in which he microwaves are 'localized'. The intensity measured at one hot spot 4.6 m from the transmitter is the same as that at 0.1 m from the transmitter in the case with out reflection (free boundary condition). Namely, the intensity at the hot spot is increased by ***approximately 2000 times*** *by reflection."* Emphasis added

"To confirm our experimental findings of the greater-than-predicted intensity due to reflection, as well as the hot spots, we performed two numerical simulations...". " intensity does not monotonically decrease from the transmitter, which is in clear contrast to the case without reflection."

"The intensity at the hot spot (X, Y, Z) = 1.46, -0.78, 105) around 1.8 m from the transmitter in the reflective boundary condition is ***approximately 1000 times higher*** *than that at the same position in the free boundary condition. The result of the simulation is thus consistent with our experiments, although the values differ owing to the different conditions imposed by computational limits."*

Emphasis added

"(t)he result of the experiment is also reproduced: a greater than predicted intensity due to reflection, as well as the existence of hot spots."

"In comparison with the control simulation using the free boundary condition, we find that the power density at the hot spot is increased ***by approximately a thousand times*** *by reflection."*

Emphasis added

Further, the author comments that:

"we may be passively exposed beyond the levels reported for electro-medical interference and health risks."

"Because the peak exposure level is crucial in considering electro-medical interference, interference (in) airplanes, and biological effects on human beings, we also need to consider the possible peak exposure level, or 'hot spots', for the worst-case estimation."

Reflections and re-radiation from common building material (tile, concrete, stainless steel, glass, ceramics) and highly reflective appliances and furnishings are common in kitchens, for example. Using only low reflectivity FCC equations 6 and 10 may not be informative. Published studies underscore how use of even the highest reflection coefficient in FCC OET Bulletin 65 Equations 6 and 10 likely underestimate the potential for reflection and hot spots in some situations in real-life situations.

This report includes the FCC's reflection factors of 60% and 100%, and also

reflection factors of 1000% and 2000% that are more in line with those reported in Hondou, 2001; Hondou, 2006 and Vermeeren et al, 2010. The use of a 1000% reflection factor in this report is still conservative in comparison to Hondou, 2006. A 1000% reflection factor is 12% of Hondou's larger power density prediction (or 121 times, rather than 1000 times)/ The 2000% reflection factor is 22% of Hondou's figure (or 441 times in comparison to 2000 times higher power density in Hondou, 2006).

Peak Power Limits

In addition to time-averaged public safety limits that require RF exposures to be time-averaged over a 30 minute time period, the FCC also addresses peak power exposures. The FCC refers back to the ANSI/IEEE C95.1-1992 standard to define what peak power limits are.

The ANSI/IEEE C95.1-1999 standard defines peak power density as "*the maximum instantaneous power density occurring when power is transmitted*." (p. 4) Thus, there is a second method to test FCC compliance that is not being assessed in any FCC Grants of Authorization.

> *"Note that although the FCC did not explicitly adopt limits for peak power density, guidance on these types of exposures can be found in Section 4.4 of the ANSI/IEEE C95.1-1992 standard."*
>
> *Page 10, OET 65*

The ANSI/IEEE limit for peak power to which the FCC refers is:

> *"For exposures in uncontrolled environments, the peak value of the mean squared field strengths should not exceed 20 times the square of the allowed spatially averaged values (Table 2) at frequencies below 300 MHz, or <u>the equivalent power density of 4 mW/cm2 for f between 300 MHz and 6 GHz</u>".*

The peak power exposure limit is 4000 uW/cm2 for all smart meter frequencies (all transmitting antennas) for any instantaneous RF exposure of 4 milliwatts/cm2 (4 mW/cm2) or higher which equals 4000 microwatts/cm2 (uW/cm2).

This peak power limit applies to all smart meter frequencies for both the smart meter (two-antenna configuration) and the collector meter (three-antenna configuration). All these antennas are within the 300 MHz to 6 GHz frequency range where the 4000 uW/cm2 peak power limit applies (Table 3, ANSI/IEEE C95.1-1999, page 15).

Smart meters emit frequencies within the 800 MHz to 2400 MHz range.

Exclusions

This peak power limit applies to all parts of the body with the important exception of the eyes and testes.

The ANSI/IEEE C95.1-1999 standard specifically excludes exposure of the eyes and testes from the peak power limit of 4000 uW/cm2*. However, nowhere in the ANSI/IEEE nor the FCC OET 65 documents is there a lower, more protective peak power limit given for the eyes and testes (see also Appendix C).

> *"The following relaxation of power density limits is allowed for exposure of all parts of the body <u>except the eyes and testes</u>." (p.15)*
>
> *"Since most exposures are not to uniform fields, a method has been derived, based on the demonstrated peak to whole-body averaged SAR ratio of 20, for equating nonuniform field exposure and partial body exposure to an equivalent uniform field exposure. This is used in this standard to allow relaxation of power density limits for partial body exposure<u>, except in the case of the eyes and the testes</u>." (p.20)*

"In the case of the eyes and testes, direct relaxation of power density limits is not permitted."(p. 30)

*Note: This leaves unanswered what instantaneous peak power is permissible from smart meters. The level must be below 4000 uW/cm2. This report shows clearly that smart meters can create instantaneous peak power exposures where the face (eyes) and body (testes) are going to be in close proximity to smart meter RF pulses. RF levels at and above 4000 uW/cm2 are likely to occur if a person puts their face close to the smart meter to read data in real time. The digital readout of the smart meter requires close inspection, particularly where there is glare or bright sunlight, or low lighting conditions. Further, some smart meters are installed inside buildings within inches of occupied space, virtually guaranteeing exposures that may violate peak power limits. Violations of peak power limits are likely in these circumstances where there is proximity within about 6" and highly reflective surfaces or metallic objects. The eyes and testes are not adequately protected by the 4000 uW/cm2 peak power limit, and in the cases described above, may be more vulnerable to damage (Appendix C for further discussion).

METHODOLOGY

Radiofrequency fields associated with SMART Meters were calculated following the methodology described here. Prediction methods specified in Federal Communications Commission, Office of Engineering and Technology Bulletin 65 Edition 97-01, August 1997 were used in the calculations.[1]

Section 2 of FCC OET 65 provides methods to determine whether a given facility would be in compliance with guidelines for human exposure to RF radiation. We used equation (3)

$$S = \frac{P \times G \times \partial}{4 \times \pi \times R^2} = \frac{EIRP \times \partial}{4 \times \pi \times R^2} = \frac{1.64 \times ERP \times \partial}{4 \times \pi \times R^2}$$

where:

S = power density (in µW/cm^2)
P = power input to the antenna (in W)
G = power gain of the antenna in the direction of interest relative to an isotropic radiator
∂ = duty cycle of the transmitter (percentage of time that the transmitter actually transmits over time)
R = distance to the center of radiation of the antenna
EIRP = PG
ERP = 1.64 EIRP

where:

EIRP = is equivalent (or effective) isotropically radiated power referenced to an isotropic radiator
ERP = is equivalent (or effective) radiated power referenced to a half-wave dipole radiator

Analysis input assumptions

1. SMART Meters [SK9AMI-4] have two RF transmitters (antennas) and are the type of smart meters typically installed on most buildings. They contain two antennas that transmit RF signals (916 MHz LAN and 2405 MHz Zigbee). The antennas CAN transmit simultaneously, and thus the maximum RF exposure is determined by the summation of power densities (from the FCC Certification Exhibit titled RF Exposure Report for FCC ID: SK9AMI-4).

   Model SK9AMI-4 transmits on 915 MHz is designated as LAN Antenna Gain for each model.

   a. Transmitter Power Output (TPO) used is as shown on the grant issued by the Telecommunications Certification Body (TCB).

   b. Antenna gain in dBi (decibels compared to an isotropic radiator) used comes from the ACS Certification Exhibit.

2. Collector Meters [SK9AMI-2A] have three RF transmitters (antennas) and are installed where the utility needs them to relay RF signals from surrounding smart meters in a neighborhood. Collector meters contain a third antenna (GSM 850 MHz, 915 MHz LAN and 2405 MHz Zigbee). Collector meters can be placed on any building where a collector meter is needed to relay signals from the surrounding area. Estimates of the number of collector meters varies between one per 500 to one per 5000 smart meters. Collector meters will thus 'piggyback' the RF signals of hundreds or thousands of smart meters through the one collector meter. In a collector meter, only two of the three antennas can transmit simultaneously (the 915 MHz LAN and the GSM 850 MHz (from the FCC Certification Exhibit titled RF Exposure Report for FCC ID: SK9AMI-2A).

3. The Cell Relay transmitting at 2480 MHz is <u>not</u> on most meters and <u>not</u> considered in this analysis.

   a. Transmitter Power Output (TPO) used is as shown on the grant issued by the Telecommunications Certification Body (TCB).

   b. Antenna gain in dBi (decibels compared to an isotropic radiator) used comes from the ACS Certification Exhibit.

ERP (Effective Radiated Power) used in the computer modeling here is calculated using the TPO and antenna gain established for each model

Red figures used to Calculate ERP		**ACS and TCB Certification data sheet**							
		SK9AMI-2A				**SK9AMI-4**			
		ACS			TCB	**ACS**			TCB
Radio	Frequency	dBm	Watts	dBi	Watts	dBm	Watts	dBi	Watts
GSM	850	31.8	1.5136	-1.0					
LAN	915	21.92	0.1556	3.0		24.27	0.2673	**2.2**	**0.267**
LAN	916								0.257
GSM	1900	28.7	0.7413	1.0					
Register	2405	18.71	0.0743	**1.0**	**0.074**	19.17	0.0826	4.4	
Cell Relay	2480	-14.00	0.00004	4.00					

Assumptions: TPO per TCB , Antenna Gain per ACS Certification

ERP Calculation: **Bold** figures are used for single meter ERP in modeling

Type	TPO	dBi	dB	Mult	ERP	Freq	
1900 GSM	0.741	1.0	-1.15	0.77	0.5689	1900	
850 GSM	1.514	-1.0	-3.15	0.48	0.7328	850	Model
RFLAN	0.267	2.2	0.05	1.01	**0.2704**	915	SK9AMI-4
ZIG BEE	0.074	1.0	-1.15	0.77	**0.0570**	2405	SK9AMI-2A

<u>Reflection Factor</u>

This equation is modified with the inclusion of a ground reflection factor as recommended by the FCC. The ground reflection factor accounts for possible ground reflections that could enhance the resultant power density. A 60% (0.6) enhancement would result in a 1.6 (1 + 0.6) increase of the field strength or a 2.56 = $(1.6)^2$ increase in the power density. Similar increases for larger enhancements of the field strength are calculated by the square of the original field plus the enhancement percentage. [2.3.4]

<u>Reflection Factors:</u>

60% = $(1 + 0.6)^2$ = 2.56 times
100% = $(1 + 1)^2$ = 4 times
1000% = $(1 + 10)^2$ = 121 times
2000% = $(1 + 20)^2$ = 441 times

Duty Cycle

How frequently SMART Meters can and will emit RF signals from each of the antennas within the meters is uncertain, and subject to wide variations in estimation. For this reason, and because FCC OET 65 mandates a 100% duty cycle (continuous exposure where the public cannot be excluded) the report gives RF predictions for all cases from 1% to 100% duty cycle at 10% intervals. The reader can see the variation in RF emissions predicted at various distances from the meter (or bank of meters) using this report at all duty cycles. Thus, for purposes of this report, duty cycles have been estimated from infrequent to continuous. Duty cycles for SMART Meters were calculated at:

Duty cycle ∂:

1%	50%
5%	60%
10%	70%
20%	80%
30%	90%
40%	100%

Continuous Exposure

FCC Bulletin OET 65 and the ANSI/IEEE C95.1-1992, 1999 requires that continuous exposure be calculated for situations where there is uncontrolled public access. Continuous exposure in this case means reading the tables at 100% duty cycle.

> *"Another feature of the exposure guidelines is that exposures, in terms of power density, E2 or H2, may be averaged over certain periods of time with the average not to exceed the limit for continuous exposure.*[11]

"As shown in Table 1 of Appendix A, the averaging time for occupational/controlled exposures is 6 minutes, while the averaging time for general population/uncontrolled exposures is 30 minutes. It is important to note that for general population/uncontrolled exposures it is often not possible to control exposures to the extent that averaging times can be applied. In those situations, it is often necessary to assume continuous exposure." (FCC OET 65, Page 15)

Calculation Distances in Tables (3-inch increments)

Calculations were performed in 3-inch (.25 foot) increments from the antenna center of radiation. Calculations have been taken out to a distance of 96 feet from the antenna center for radiation for each of the conditions above. The antenna used for the various links in a SMART Meter is assumed to be at the center of the SMART Meter from front to back – approximately 3 inches from the outer surface of the meter.

Calculations have also been made for a typical nursery and kitchen. In the nursery it has been assumed that the baby in his or her crib that is located next to the wall where the electric SMART Meters are mounted. The closest part of the baby's body can be as close as 11 inches* from the meter antenna. In the kitchen it has been assumed that a person is standing at the counter along the wall where the electric SMART Meters are mounted. In that case the closest part of the adult's body can be located as close to the meter antenna as 28 inches.

The exposure limits are variable according to the frequency (in megahertz). Table 1, Appendix A show exposure limits for occupational (Part A) and uncontrolled public (Part B) access to radiofrequency radiation such as is emitted from AM, FM, television and wireless sources.

* Flush-mounted main electric panels that house smart meters are commonly installed; placing smart meters 5” 6” closer to occupied space than box-mounted main electric panels that sit outward on exterior building walls. Assumptions on spacing are made for flush-mounted panels.

Conditions Influencing Radiofrequency Radiation Level Safety

The location of the meter in relation to occupied space, or outside areas of private property such as driveways, walk-ways, gardens, patios, outdoor play areas for children, pet shelters and runs, and many typical configurations can place people in very close proximity to smart meter wireless emissions. In many instances, smart meters may be within inches or a few feet of occupied space or space that is used by occupants for daily activities.

Factors that influence how high RF exposures may be include, but are not limited to where the meter is installed in relation to occupied space, how often the meters are emitting RF pulses (duty cycle), and what reflective surfaces may be present that can greatly intensify RF levels or create 'RF hot spots' within rooms, and so on. In addition, there may be multiple wireless meters installed on some multi-family residential buildings, so that a single unit could have 20 or more electric meters in close proximity to each other, and to occupants inside that unit. Finally, some meters will have higher RF emissions, because – as collector units – their purpose is to collect and resend the RF signals from many other meters to the utility. A collector meter is estimated to be required for every 500 to 5000 buildings. Each collector meter contains three, rather than two transmitting antennas. This means higher RF levels will occur on and inside buildings with a collector meter, and significantly more frequent RF transmissions can be expected. At present, there is no way to predict whose property will be used for installation of collector meters.

People who are visually reading the wireless meters 'by sight' or are visually inspecting and/or reading the digital information on the faceplate may have

their eyes and faces only inches from the antennas.

Current standards for peak power limit do not have limits to protect the eyes and testes from instantaneous peak power from smart meter exposures, yet relevant documents identify how much more vulnerable these organs are, and the need for such safety limits to protect the eyes and testes.

No Baseline RF Assessment

Smart meter and collector meter installation are taking place in an information vacuum. FCC compliance testing takes place in an environment free of other sources of RF, quite unlike typical urban and some rural environments. There is no assessment of baseline RF conditions already present (from AM, FM, television and wireless communication facilities (cell towers), emergency and dispatch wireless, ham radio and other involuntary RF sources. Countless properties already have elevated RF exposures from sources outside their own control.

Consumers may also have already increased their exposures to radiofrequency radiation in the home through the voluntary use of wireless devices (cell and cordless phones), PDAs like BlackBerry and iPhones, wireless routers for wireless internet access, wireless home security systems, wireless baby surveillance (baby monitors), and other emerging wireless applications.

Neither the FCC, the CPUC, the utility nor the consumer know what portion of the allowable public safety limit is already being used up or pre-empted by RF from other sources already present in the particular location a smart meter may be installed and operated.

Consumers, for whatever personal reason, choice or necessity who have already eliminated all possible wireless exposures from their property and lives, may now face excessively high RF exposures in their homes from smart meters. This may force limitations on use of their otherwise occupied space, depending on how the meter is located, building materials in the structure, and how it is furnished.

RESULTS, FINDINGS AND CONCLUSIONS

The installation of wireless 'smart meters' in California can produce significantly high levels of radiofrequency radiation (RF) depending on many factors (location of meter(s) in relation to occupied or usable space, duty cycle or frequency of RF transmissions, reflection and re-radiation of RF, multiple meters at one location, collector meters, etc).

Power transmitters that will relay information from appliances inside buildings with wireless smart meters produce high, localized RF pulses. Any appliance that contains a power transmitter (for example, dishwashers, washers, dryers, ranges and ovens, convection ovens, microwave ovens, flash water heaters, refrigerators, etc) will create another 'layer of RF signals' that may cumulatively increase RF exposures from the smart meter(s).

It should be emphasized that no single assertion of compliance can adequately cover the vast number of site-specific conditions in which smart meters are installed. These site-specific conditions determine public exposures and thus whether they meet FCC compliance criteria.

Tables in this report show either distance to an FCC safety limit (in inches) or they show the predicted (calculated) RF level at various distances in microwatts per centimeter squared (uW/cm2).

Both depictions are useful to document and understand RF levels produced by smart meters (or multiple smart meters) and by collector meters (or collections of one collector and multiple smart meters).

Large differences in the results of computer modeling occur in this report by

bracketing the uncertainties (running a sufficient number of computer scenarios) to account for variability introduced by possible duty cycles and possible reflection factors.

FCC equations from FCC OET 65 provide for calculations that incorporate 60% or 100% reflection factors. Studies cited in this report document higher possible reflections (in highly reflective environments) and support the inclusion of higher reflection factors of 1000% and 2000% based on Vermeeren et al, 2010, Hondou et al, 2006 and Hondou, 2002. Tables in the report provide the range of results predicted by computer modeling for duty cycles from 1% to 100%, and reflection factors of 60%, 100%, 1000%, and 2000% for comparison purposes. FCC violations of time-weighted average calculations and peak power limit calculations come directly from FCC OET 65 and from ANSI/IEEE c95.1-1992, 1999. Duty cycle (or how frequently the meters will produce RF transmissions leading to elevated RF exposures) is uncertain, so the full range of possible duty cycles are included, based on best available information at this date.

- Tables 1-2 show radiofrequency radiation (RF) levels at 6" (to represent a possible face exposure). These are data tables.
- Tables 3-4 show RF levels at 11" (to represent a possible nursery/bedroom exposure). These are data tables.
- Tables 5-6 show RF levels at 28" to represent a possible kitchen work space exposure. These are data tables.
- Tables 7-9 show the distance to the FCC violation level for time-weighted average limits and for peak power limits (in inches). These are data tables.
- Tables 10-15 show where FCC violations may occur at the face, in the nursery or in the kitchen scenarios. These are colored tables

highlighting where FCC violations may occur under all scenarios.

- Tables 16-29 show comparisons of smart meter RF levels with studies that report adverse health impacts from low-intensity, chronic exposure to similar RF exposures. These are colored tables highlighting where smart meter RF levels exceed levels associated with adverse health impacts in published scientific studies.
- Tables 30-31 show RF levels in comparison to Medtronics advisory limit for MRI exposures to radiofrequency radiation at 0.1 W/Kg or about 250 uW/cm2. These are colored tables highlighting where smart meter RF levels may exceed those recommended for RF exposure.
- Tables 32-33 show RF levels from smart meters in comparison to the BioInitiative Report recommendation of 0.1 uW/cm2 for chronic exposure to pulsed radiofrequency radiation.

Findings

RF levels from the various scenarios depicting normal installation and operation, and possible FCC violations have been determined based on both time-averaged and peak power limits (Tables 1 - 14).

Potential violations of current FCC public safety standards for smart meters and/or collector meters in the manner installed and operated in California are illustrated in this Report, based on computer modeling (Tables 10 – 17).

Tables that present data, possible conditions of violation of the FCC public safety limits, and comparisons to health studies reporting adverse health impacts are summarized (Tables 18 – 33).

Where do predicted FCC violations occur for the 655 uW/cm2 time-averaged public safety limit at the face at 6” distance from the meter?

Table 10 shows that for <u>one smart meter</u>, no violations are predicted to occur at 60% or 100% reflection factor at any duty cycle, but violations are predicted to occur with nearly all scenarios using either 1000% or 2000% reflection factors.

Table 10 also shows that for <u>multiple smart meters</u>, FCC violations are predicted to occur at 60% reflection factor @ 50% to 100% duty cycles; and also at 100% reflection factor @ 30% to 100% duty cycle. All scenarios using either 1000% or 2000% reflection factors indicate FCC violations can occur (or conservatively at 12% to 22% of those in Hondou et al, 2006).

Table 11 shows that for <u>one collector meter</u>, one violation occurs at 60% @ 100% duty cycle; and at 100% reflection factor for duty cycles between 60% and 100%. Violations are predicted to occur at all scenarios using either 1000% or 2000% reflection factors.

Table 11 also shows that for <u>one collector meter plus multiple smart meters</u>, FCC violations can occur at 60%reflection factor @ 40% to 100% duty cycles; and also at 100% reflection factor @ 30% to 100% duty cycle. All scenarios using either 1000% or 2000% reflection factors indicate FCC violations can occur.

Where do predicted FCC violations occur for the 655 uW/cm2 time-averaged public safety limit in the nursery crib at 11" distance?

Table 12 shows that for <u>one smart meter</u>, no violations are predicted to occur at 60% or 100% reflection factor at any duty cycle, but violations would be predicted with nearly all scenarios using either 1000% or 2000% reflection factors.

Table 12 also shows that for <u>multiple smart meters</u>, no FCC violations are predicted to occur at 60% reflection factor at any duty cycle; and also at 100% reflection factor @ 90% and 100% duty cycle. All scenarios using either 1000% or 2000% reflection factors indicate FCC violations can occur.

Table 13 shows that for <u>one collector meter</u>, one violation occurs at 100% reflection @100% duty cycle. No violations at 60% reflection are predicted. Violations are predicted to occur at all scenarios using 1000% reflection except @ 1% duty cycle. All 2000% reflection scenarios indicate FCC violations can occur.

Table 13 shows that for one collector meter plus multiple smart meters, FCC violations are not predicted to occur at 60% reflection factor. At 100% reflection factor, violations are predicted at 60% to100% duty cycles. FCC violations are predicted for all1000% and 2000% reflection factors with the exception of 1000% reflection at 1% duty cycle.

Where do predicted FCC violations occur for the 655 uW/cm2 time-averaged public safety limit in the kitchen work space at 28" distance?

Table 14 shows that for one smart meter, no violations are predicted to occur at 60% or 100% reflection factor at any duty cycle. Violations would be predicted with scenarios of 1000% reflection @ 70% to 100% duty cycles and at 2000% reflection factor @ 20% to 100% duty cycles.

Table 14 also shows that for multiple smart meters, no FCC violations are predicted to occur at 60% or at the 100% reflection factors at any duty cycle. Violations are predicted at 1000% reflection factor @ 70% to 100% duty cycles and at 2000% reflection factor @20% to 100% duty cycles.

Table 15 shows that for one collector meter, one violation occurs at 100% reflection @100% duty cycle. No violations at 60% reflection are predicted. Violations are predicted to occur at all scenarios using 1000% reflection except @ 1% duty cycle. All 2000% reflection scenarios indicate FCC violations can occur.

Table 15 shows that for one collector meter plus multiple smart meters, FCC violations are not predicted to occur at 60% or at 100% reflection factors at any duty cycle. At 1000% reflection factor, violations are predicted at 30% to 100% duty cycles. FCC violations are also predicted at 2000% reflection factor @10 to 100% duty cycles.

Where can peak power limits be violated? The peak power limit of 4000 uW/cm2 instantaneous public safety limit at 3" distance? This limit may be exceeded wherever smart meters and collector meters (face plate or any portion within 3" of the internal antennas can be accessed directly by the public.

Table 16 shows that for one smart meter, no violations are predicted to occur at 60% or 100% reflection factor at any duty cycle. Peak power limit violations would be predicted with scenarios of 1000% reflection @ 10% to

100% duty cycles and at 2000% reflection factor @ 10% to 100% duty cycles.

Table 16 also shows that for multiple smart meters, peak power limit violations are predicted to occur at 60% reflection @ 60% to 100% duty cycle and for 100% reflection @ 40% to 100% duty cycles. Violations are predicted at 1000% reflection factor @ 10% to 100% duty cycles and at 2000% reflection factor @1% to 100% duty cycles.

Table 17 shows that for one collector meter, peak power limit violations are predicted to occur at 60% reflection @80% to 100% duty cycles and at 100% reflection @ 50% to 100% duty cycles. Violations of peak power limit are predicted to occur at all scenarios using 1000% reflection except @ 1%; and for 2000% reflection violations of peak power limit are predicted at all duty cycles.

Table 17 shows that for one collector meter plus multiple smart meters, peak power limit violations are predicted to occur at 60% @ 40% to 100% and 100% reflection @ 30% to 100% duty cycles. At 1000% and 2000% reflection factors, peak power limit violations are predicted at all duty cycles.

Where are RF levels associated with inhibition of DNA repair in human stem cells at 92.5 uW/cm2 exceeded the in the nursery crib at 11” distance?

Table 18 shows that for one smart meter, RF exposures associated with inhibition of DNA repair in human stem cells are predicted to occur at 60% reflection factor@ 70% to 100% duty cycles, and at 100% reflection factor @ 50% to 100% duty cycles. All scenarios using either 1000% or 2000% reflection factors exceed these RF exposures except 1000% at 1% duty cycle.

Table 18 also shows that for multiple smart meters, RF exposures associated with inhibition of DNA repair in human stem cells are predicted to occur at 60% reflection factor@ 20% to 100% duty cycles, and at 100% reflection factor @ 20% to 100% duty cycles. All scenarios using either 1000% or 2000% reflection factors exceed these RF exposure levels except 1000% at 1% duty cycle.

Table 19 shows that for one collector meter, RF exposures associated with inhibition of DNA repair in human stem cells are predicted to occur at 60% reflection factor@ 30% to 100% duty cycles, and at 100% reflection factor @ 20% to 100% duty cycles. All scenarios using either 1000% or 2000% reflection factors exceed these RF exposure levels.

Table 19 shows that for one collector meter plus multiple smart meters, RF exposures associated with inhibition of DNA repair in human stem cells are predicted to occur at 60% reflection factor@ 20% to 100% duty cycles, and at 100% reflection factor @ 10% to 100% duty cycles. All scenarios using either 1000% or 2000% reflection factors exceed these RF exposure levels. *Where are RF levels associated with pathological leakage of the blood-brain barrier at 0.4 – 8 uW/cm2 exceeded the in the nursery crib at 11" distance?*

Table 20 shows that for one smart meter, RF exposures associated with pathological leakage of the blood-brain barrier at 8 uW/cm2 are predicted to occur at 60% reflection factor@ 10% to 100% duty cycles, and at 100% reflection factor @ 5% to 100% duty cycles. RF levels at 0.4 uW/cm2 (the lower end of the range) are exceeded at all duty cycles and at all reflection factors in the nursery in the crib.

Table 20 also shows that for multiple smart meters, RF exposures associated with pathological leakage of the blood-brain barrier at 8 uW/cm2 are predicted to occur at 60% reflection factor@ 5% to 100% duty cycles, and at 100% reflection factor @ 5% to 100% duty cycles. RF levels at 0.4 uW/cm2 (the lower end of the range) are exceeded at all duty cycles and at all reflection factors in the nursery in the crib.

Table 21 shows that for one collector meter, RF exposures associated with pathological leakage of the blood-brain barrier at 8 uW/cm2 are predicted to occur at 60% reflection factor@ 5% to 100% duty cycles, and at 100% reflection factor @ 5% to 100% duty cycles. RF levels at 0.4 uW/cm2 (the lower end of the range) are exceeded at all duty cycles and at all reflection factors in the nursery in the crib.

Table 21 shows that for one collector meter plus multiple smart meters, .RF exposures associated with pathological leakage of the blood-brain barrier at 8 uW/cm2 are predicted to occur at 60% reflection factor@ 5% to 100% duty cycles, and at 100% reflection factor @ 1% to 100% duty cycles. RF levels at 0.4 uW/cm2 (the lower end of the range) are exceeded at all duty cycles and at all reflection factors in the nursery in the crib.

Where are RF levels associated with adverse neurological symptoms, cardiac problems and increased cancer risk exceeded in the nursery crib at 11" distance?

Table 22 shows that for one smart meter, RF exposures associated with adverse neurological symptoms above 0.1 uW/cm2 are exceeded at all duty cycles and at all reflection factors in the nursery in the crib.

Table 22 shows that for multiple smart meters, RF exposures associated with adverse neurological symptoms above 0.1 uW/cm2 are exceeded at all duty cycles and at all reflection factors in the nursery in the crib.

Table 23 shows that for one collector meter, RF exposures associated with adverse neurological symptoms above 0.1 uW/cm2 are exceeded at all duty cycles and at all reflection factors in the nursery in the crib.

Table 23 shows that for one collector meter plus multiple smart meterss, RF exposures associated with adverse neurological symptoms above 0.1 uW/cm2 are exceeded at all duty cycles and at all reflection factors in the nursery in the crib.

Where are RF levels associated with inhibition of DNA repair in human stem cells at 92.5 uW/cm2 exceeded the in the kitchen work space at 28" distance?

Table 24 shows that for one smart meter, RF levels do not exceed those associated with inhibition of DNA repair at 60% or 100% reflection factor at any duty cycle. RF levels are exceeded at 1000% @ 10% to 100% duty cycles; and at 2000% reflection factor @ 5% to 100% duty cycles.

Table 24 also shows that for multiple smart meters, RF levels do not exceed those associated with inhibition of DNA repair at 60% or 100% reflection factor at any duty cycle. RF levels are exceeded at 1000% @ 5% to 100% duty cycles; and at 2000% reflection factor @ 1% to 100% duty cycles.

Table 25 shows that for one collector meter, RF levels do not exceed those associated with inhibition of DNA repair at 60% at any duty cycle; at 100% reflection factor they are exceeded at 70% to 100% duty cycles.. RF levels are exceeded at 1000% @ 5% to 100% duty cycles; and at 2000% reflection factor @ 1% to 100% duty cycles.

Table 25 shows that for one collector meter plus multiple smart meters, RF levels exceed those associated with inhibition of DNA repair at 60% reflection@100% duty cycle; at 100% reflection factor they are exceeded at 70% to 100% duty cycles.. RF levels are exceeded at 1000% @ 5% to 100% duty cycles; and at 2000% reflection factor @ 1% to 100% duty cycles.

Where are RF levels associated with pathological leakage of the blood-brain barrier and neuron death at 0.4 – 8 uW/cm2 risk in the kitchen work space at 28" distance?

Table 26 shows that for one smart meter, RF exposures associated with pathological leakage of the blood-brain barrier at 8 uW/cm2 are predicted to occur at 60% reflection factor@ 40% to 100% duty cycles, and at 100% reflection factor @ 30% to 100% duty cycles, and at all 1000% and 2000% reflections. RF levels at 0.4 uW/cm2 (the lower end of the range) are exceeded at all duty cycles and at all reflection factors in the kitchen work space except at 1% duty cycle for 60% and 100% reflections.

Table 26 also shows that for multiple smart meters, RF exposures associated with pathological leakage of the blood-brain barrier at 8 uW/cm2 are predicted to occur at 60% reflection factor@ 30% to 100% duty cycles, and at 100% reflection factor @ 20% to 100% duty cycles, and at all 1000% and 2000% reflections. RF levels at 0.4 uW/cm2 (the lower end of the range) are exceeded at all duty cycles and at all reflection factors in the kitchen.

Table 27 shows that for one collector meter, RF exposures associated with pathological leakage of the blood-brain barrier at 8 uW/cm2 are predicted to occur at 60% reflection factor@ 20% to 100% duty cycles, and at 100% reflection factor @ 10% to 100% duty cycles. RF levels at 0.4 uW/cm2 (the lower end of the range) are exceeded at all duty cycles and at all reflection factors in the kitchen work space.

Table 27 shows that for one collector meter plus multiple smart meters, .RF exposures associated with pathological leakage of the blood-brain barrier at 8 uW/cm2 are predicted to occur at 60% reflection factor@ 20% to 100% duty cycles, and at 100% reflection factor @ 20% to 100% duty cycles. RF levels at 0.4 uW/cm2 (the lower end of the range) are exceeded at all duty cycles and at all reflection factors in the kitchen work space.

Where are RF levels associated with adverse neurological symptoms, cardiac problems and increased cancer risk in the kitchen work space at 28" distance?

Table 28 shows that for <u>one smart meter</u>, RF exposures associated with adverse neurological symptoms above 0.1 uW/cm2 are exceeded at all duty cycles and at all reflection factors in the kitchen work space.

Table 28 shows that for <u>multiple smart meters</u>, RF exposures associated with adverse neurological symptoms above 0.1 uW/cm2 are exceeded at all duty cycles and at all reflection factors in the kitchen work space.

Table 29 shows that for <u>one collector meter</u>, RF exposures associated with adverse neurological symptoms above 0.1 uW/cm2 are exceeded at all duty cycles and at all reflection factors in the kitchen work space.

Table 29 shows that for <u>one collector meter plus multiple smart meterss</u>, RF exposures associated with adverse neurological symptoms above 0.1 uW/cm2 are exceeded at all duty cycles and at all reflection factors in the kitchen work space.

Where do RF levels exceed the Medtronics Safety Advisory?

Table 30: At no duty cycles for either 60% or 100% reflection factors; between 10% and 100% duty factors for 1000% and between 5% and 100% duty factors for 2000% reflection (for one smart meter).

Table 30: At 60% reflection @ 60% to 100% duty cycle; and at 100% reflection @ 40% to 100% duty cycle; at 1000% reflection @ 5% to 100% duty cycle and for all duty cycles at 2000% reflection (for multiple smart meters).

Table 31: At 60% reflection @ 70% to 100% duty cycle; at 100% reflection at 50% to 100% duty cycles; at 1000% reflection @ 5% to 100% and at all duty cycles for 2000% reflection (for one collector meter).

Table 31: At 60% reflection @ 40% to 100% duty cycle; at 100% reflection at 30% to 100% duty cycles; and at all duty cycles for both 1000% reflection and for 2000% reflection (for one collector meter plus three smart meters).

Where are RF levels associated with smart meters in all their configurations (one meter, multiple smart meters, one collector meter, one collector plus multiple smart meters) above those recommended in the BioInitiative Report (2007)?

Tables 32 and 33 depict the distance from the center of radiation for the smart meter(s) and collector meter scenarios in feet. The distances (in feet) at which RF levels exceed the BioInitiative Report recommended limit of 0.1 uW/cm2 is as small as 3.4' (one smart meter at 60% reflection and 1% duty cycle). At 60% reflection and 100% duty cycle, the distance to the BioInitiative recommended limit increases to 34 feet for one smart meter.

When multiples of smart meters are considered, the shortest distance to where the BioInitiative Report recommended limit is exceeded is 9.7 feet (for 60% reflection @ 1% duty cycle). It increases to 97' @100% duty cycle for multiple smart meters.

For a single collector meter, the shortest distance to a BioInitiative Report exceedence is 5.9 feet (60% reflection @ 1% duty cycle). At 60% reflection and 100% duty cycle, it increases to 59 feet.

For a collector and multiple smart meters, the shortest distance is 10.9 feet at 60% reflection @ 1% duty cycle, and increases to108 feet at 100% duty cycle.

Conclusions

FCC compliance violations are likely to occur under widespread conditions of installation and operation of smart meters and collector meters in California. Violations of FCC safety limits for uncontrolled public access are identified at distances within 6" of the meter. Exposure to the face is possible at this distance, in violation of the time-weighted average safety limits (Tables 10-11). FCC violations are predicted to occur at 60% reflection and 100% reflection factors*, both used in FCC OET 65 formulas for such calculations for time-weighted average limits. Peak power limits are not violated at the 6" distance (looking at the meter) but can be at 3"

from the meter, if it is touched.

This report has also assessed the potential for FCC violations based on two examples of RF exposures in a typical residence. RF levels have been calculated at distances of 11" (to represent a nursery or bedroom with a crib or bed against a wall opposite one or more meters); and at 28" (to represent a kitchen work space with one or more meters installed on the kitchen wall).

FCC compliance violations are identified at 11" in a nursery or bedroom setting using Equation 10* of the FCC OET 65 regulations (Tables 12-13). These violations are predicted to occur where there are multiple smart meters, or one collector meter, or one collector meter mounted together with several smart meters.

FCC compliance violations are not predicted at 28" in the kitchen work space for 60% or for 100% reflection calculations. Violations of FCC public safety limits are predicted for higher reflection factors of 1000% and 2000%, which are not a part of FCC OET 65 formulas, but are included here to allow for situations where site-specific conditions (highly reflective environments, for example, galley-type kitchens with many highly reflective stainless steel or other metallic surfaces) may be warranted (see Methodology Section).

In addition to exceeding FCC public safety limits under some conditions of installation and operation, smart meters can produce excessively elevated RF exposures, depending on where they are installed. With respect to absolute RF exposure levels predicted for occupied space within dwellings, or outside areas like patios, gardens and walk-ways, RF levels are predicted to be substantially elevated within a few feet to within a few tens of feet from the

meter(s).

For example, one smart meter at 11" from occupied space produces somewhere between 1.4 and 140 microwatts per centimeter squared (uW/cm2) depending on the duty cycle modeled (Table 12). Since FCC OET 65 specifies that continuous exposure be assumed where the public cannot be excluded (such as is applicable to one's home), this calculation produces an RF level of 140 uW/cm2 at 11" using the FCCs lowest reflection factor of 60%. Using the FCC's reflection factor of 100%, the figures rise to 2.2 uW/cm2 – 218 uW/cm2, where the continuous exposure calculation is 218 uW/cm2 (Table 12). These are very significantly elevated RF exposures in comparison to typical individual exposures in daily life. Multiple smart meters in the nursery/bedroom example at 11" are predicted to generate RF levels from about 5 to 481 uW/cm2 at the lowest (60%) reflection factor; and 7.5 to 751 uW/cm2 using the FCCs 100% reflection factor (Table 13). Such levels are far above typical public exposures.

RF levels at 28" in the kitchen work space are also predicted to be significantly elevated with one or more smart meters (or a collector meter alone or in combination with multiple smart meters). At 28" distance, RF levels are predicted in the kitchen example to be as high as 21 uW/cm2 from a single meter and as high as 54.5 uW/cm2 with multiple smart meters using the lower of the FCCs reflection factor of 60% (Table 14).

Using the FCCs higher reflection factor of 100%, the RF levels are predicted to be as high as 33.8 uW/cm2 for a single meter and as high as 85.8 uW/cm2 for multiple smart meters (Table 14). For a single collector meter, the range is 60.9 to 95.2 uW/cm2 (at 60% and 100% reflection factors, respectively)

(from Table 15).

Table 16 illustrates predicted violations of peak power limit (4000 uW/cm2) at 3" from the surface of a meter. FCC violations of peak power limit are predicted to occur for a single collector meter at both 60% and 100% reflection factors. This situation might occur if someone touches a smart meter or stands directly in front.

Uncertainty About Actual RF Levels

Consumers may also have already increased their exposures to radiofrequency radiation in the home through the voluntary use of wireless devices (cell and cordless phones), PDAs like BlackBerry and iPhones, wireless routers for wireless internet access, wireless home security systems, wireless baby surveillance (baby monitors), and other emerging wireless applications.

Neither the FCC, the CPUC, the utility nor the consumer know what portion of the allowable public safety limit is already being used up or pre-empted by RF from other sources already present in the particular location a smart meter may be installed and operated.

Consumers, for whatever personal reason, choice or necessity who have already eliminated all possible wireless exposures from their property and lives, may now face excessively high RF exposures in their homes from smart meters. This may force limitations on use of their otherwise occupied space, depending on how the meter is located, building materials in the

structure, and how it is furnished.

People who are afforded special protection under the federal Americans with Disabilities Act are not sufficiently acknowledged nor protected. People who have medical and/or metal implants or other conditions rendering them vulnerable to health risks at lower levels than FCC RF limits may be particularly at risk (Tables 30-31). This is also likely to hold true for other subgroups, like children and people who are ill or taking medications, or are elderly, for they have different reactions to pulsed RF. Childrens' tissues absorb RF differently and can absorb more RF than adults (Christ et al, 2010; Wiart et al, 2008). The elderly and those on some medications respond more acutely to some RF exposures.

Eyes and Testes - Safety standards for peak exposure limits to radiofrequency have not been developed to take into account the particular sensitivity of the eyes, testes and other ball shaped organs. There are no peak power limits defined for the eyes and testes, and it is not unreasonable to imagine situations where either of these organs comes into close contact with smart meters and/or collector meters, particularly where they are installed in multiples (on walls of multi-family dwellings that are accessible as common areas).

What can be determined from the relevant standards (FCC and ANSI/IEEE and certain IEEE committee documents is that the eye and testes are potentially much more vulnerable to damage, but that there is no scientific basis on which to develop a new, more protective safety limit. What is certain is that the peak power limit of 4000 uW/cm2 exceeds what is safe (Appendix C).

In summary, no positive assertion of safety can be made by the FCC, nor relied upon by the CPUC, with respect to pulsed RF when exposures are chronic and occur in the general population. Indiscriminate exposure to environmentally ubiquitous pulsed RF from the rollout of millions of new RF sources (smart meters) will mean far greater general population exposures, and potential health consequences. Uncertainties about the existing RF environment (how much RF exposure already exists), what kind of interior reflective environments exist (reflection factor), how interior space is utilized near walls), and other characteristics of residents (age, medical condition, medical implants, relative health, reliance on critical care equipment that may be subject to electronic interference, etc) and unrestrained access to areas of property where meter is located all argue for caution.

Electronic Interference

Consumers may experience electronic interference (electromagnetic interference or EMI) from smart meter wireless signals. The FCC also is charged with investigating consumer complaints about electronic interference.

> *"The FCC requires that unlicensed low-power RF devices must not create interference and users of such equipment must resolve any interference problems or cease operation. According to the FCC (47CFR Part 15): "The operator of a radio frequency device shall be required to cease operating the device upon notification by a Commission representative that the device is causing harmful interference. Operation shall not resume until the condition causing the harmful interference has been corrected."*
>
> (EPRI, 2010)

Medical and other critical care equipment in the home environment may not work, or work properly due to electronic interference from smart meters.

Security systems, surveillance monitors and wireless intercoms may be rendered inoperable or unreliable. Some cordless telephones do not work reliably, or have substantial interference from smart meter RF emissions.

Electronic equipment and electrical appliances may be damaged or have to be replaced with other, newer equipment in order not to be subject to electromagnetic interference from smart meter RF bursts.

Americans With Disabilities Act

People who have medical implants, particularly metal implants, may be more sensitive to spurious RF exposures for two reasons. Electromagnetic interference (EMI) with critical care medical equipment and medical implants is a potentially serious threat. Patients with deep-brain stimulators (Parkinson's disease patients) have reported adverse health effects due to RF from various environmental sources like security gates and RFID scanners. Patients with deep brain stimulators have reported the devices to be reprogramming or electrodes shut-down as a result of encounters with wireless RFID scanners. One manufacturer, Medtronics, has issued a warning for DBS implant patients to limit RF exposure to less than 0.1 W/Kg SAR (or sixteen times lower than for the general public) for MRI exposures.

The IEEE SC4 committee (2001) considered changes to existing ANSI/IEEE standards adopted in 1992 (C95.1-1992). They discussed vulnerable organs

(eyes, testes) and metallic implants that can intensify localized RF exposures within the body and its tissues.

> *"Question 20: Are there specific tissues or points within the body that have particularly high susceptibilities to local heating due to thermal properties in the immediate vicinity of the tissue?"*

Committee minutes include the following discussion on metallic implants.

> *"Metallic implants are an interesting example of this question. There can be very localized high field concentrations around the tips of long metal structures, in the gaps of wire loops. Of course, these metal devices don't create energy, but can only redistribute it, so the effect is limited to some extent. Also the high thermal conductivity and specific heat capacity make them good thermal sinks for any localized heat sources generated around them."*

Since deep brain stimulators in Parkinson's patients involve metal implants that are essentially long metal structures with tips that interface with brain tissue and nerves within the brain and body, exposing such patients with implants to high levels of pulsed RF that can produce localized, high RF within the body is certainly inadvisable. It is clear the IEEE SC4 committee recognized the potential risk by to calling such implanted metallic devices good 'thermal sinks' for localized heating dissipation.

The FCC's Grants of Authorization and other certification procedures do not ensure adequate safety to safeguard people under Department of Justice protection under the Americans with Disabilities Act.

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Appendix A Tables A1- A 48

RADIOFREQUENCY RADIATION VERSUS DISTANCE

One Smart Meter

Table A1	60% Reflection	(1%-100% duty cycles in each table)
Table A2	100% Reflection	(1%-100% duty cycles in each table)
Table A3	1000% Reflection*	(1%-100% duty cycles in each table)
Table A4	2000% Reflection*	(1%-100% duty cycles in each table)

Multiple Smart Meters (Four)**

Table A5	60% Reflection	(1%-100% duty cycles in each table)
Table A6	100% Reflection	(1%-100% duty cycles in each table)
Table A7	1000% Reflection	(1%-100% duty cycles in each table)
Table A8	2000% Reflection	(1%-100% duty cycles in each table)

One Collector Meter

Table AA9	60% Reflection	(1%-100% duty cycles in each table)
Table A10	100% Reflection	(1%-100% duty cycles in each table)
Table A11	1000% Reflection	(1%-100% duty cycles in each table)
Table A12	2000% Reflection	(1%-100% duty cycles in each table)

One Collector Meter + 3 SM**

Table A13	60% Reflection	(1%-100% duty cycles in each table)
Table A14	100% Reflection	(1%-100% duty cycles in each table)
Table A15	1000% Reflection	(1%-100% duty cycles in each table)
Table A16	2000% Reflection	(1%-100% duty cycles in each table)

TABLES OF CRITICAL DISTANCES IN NURSERY (CRIB AT 11") AND KITCHEN SINK (AT 28") FROM SMART METER (A17-A48)

Table A17 Nursery Set –
Table A18 One Smart Meter – Critical Distance 11" to baby in crib
Table A19 60%, 100%, 1000%, 2000% duty cycle
Table A20 1% thru 90% duty cycle

Table A21 Nursery Set –
Table A22 Eight Smart Meters – Critical Distance 11" to baby in crib

Table A23 60%, 100%, 1000%, 2000% reflection
Table A24 1% thru 100% duty cycle

Table A25 Nursery Set –
Table A26 One Collector– Critical Distance 11" to baby in crib
Table A27 60%, 100%, 1000%, 2000% reflection
Table A28 1% thru 100% duty cycle

Table A29 Nursery Set –
Table A30 One Collector Meter + 7 SM– Critical Distance 11" to baby crib
Table A31 60%, 100%, 1000%, 2000% reflection
Table A32 1% thru 100% duty cycle

Table A33 Kitchen Set –
Table A34 One Smart Meter – Critical Distance 28" to kitchen sink person
Table A35 60%, 100%, 1000%, 2000% reflection
Table A36 1% thru 100% duty cycle

Table A37 Kitchen Set -
Table A38 Eight Smart Meters – Critical Distance 28" to kitchen sink person
Table A39 60%, 100%, 1000%, 2000% reflection
Table A40 1% thru 100% duty cycle

Table A41 Kitchen Set –
Table A42 One Collector – Critical Distance 28" to kitchen sink person
Table A43 60%, 100%, 1000%, 2000% reflection

Table A44	1% thru 100% duty cycl**e**
Table A45	Kitchen Set –
Table A46	One Collector + 7 SM – Critical Distance 28” to kitchen
Table A47	60%, 100%, 1000%, 2000% reflection
Table A48	1% thru 100% duty cycl**e**

Appendix B Tables 1 – 33 of Report

Data Tables, FCC Violation Tables, Health Comparisions

(One Meter, Four Meters)

Appendix C

Other Sources of Information on sensitivity of the eyes and testes

In the most recent proposed revisions of RF safety standards, the IEEE SC4 committee (2001) deliberated at length over the problem of peak power limits and non-uniform RF exposure with respect to the eye and testes. The quotes below come from committee drafts submitted in response to questions from the committee moderator.

ANSI/IEEE standards adopted in 1992 (C95.1-1992) and 1999 revisions
June 2001 SC-4 Committee Minutes

These committee discussions are informative on the issue of particular organ sensitivity to RF, and unanswered questions and differences of opinion on the subject among members. They discussed vulnerable organs (eyes, testes) and metallic implants that can intensify localized RF exposures within the body and its tissues (see also discussion on metallic implants).

Question 20: Are there specific tissues or points within the body that have particularly high susceptibilities to local heating due to thermal properties in the immediate vicinity of the tissue?

Committee minutes include the following discussion on the particular sensitivities of 'ball shaped' organs including the eyes and testes.

"*Eye balls are commonly regarded as the critical organ*"

"In the range of a few GHz (gigahertz)*, reasonances may occur in ball shaped eyes and testes. They are also electrically and thermally partly insulated from other tissues. Additionally these organs or some of their parts (lens) are thermally a little bit more vulnerable than other tissues."*

"(m)odeling has noted that rapid changes in dielectrics such as cerebral spinal fluid in the ventricles of the brain and surrounding brain tissue lead to high calculated SARs. Secondly, exposure of the eye to microwave

radiation can lead to increased temperature that is sufficient to damage tissues. The temperature rise will, of course, depend on the intensity of the irradiation, how well the energy is coupled into tissues, and how well the deposited energy is removed by normal mechanisms such as conduction and blood flow. Microwaves at the lower frequencies will be deposited deeper in the eye, while at higher frequencies they will be absorbed near the front surface of the eye. The eye does not efficiently remove heat deposited internally by microwave exposure. The main avenue of heat removal is conduction and blood flow through the retina and choroid. The lens has been thought to be the most vulnerable tissue since it has no blood flow. Other than conduction through the sclera and convection from the surface of the cornea, heat removal is poor compared to other body tissues. Because the lens is avasular it has been thought to be particularly sensitive to thermal effects of microwave exposure. These facts have led many investigators to postulate that the poor heat dissipation from within the eye of humans and other animals may lead to heat buildup and subsequent thermal damage."

"Eyes do not have good blood circulation and testes have lower than body temperature."

"These organs are not well-perfused, hence have been singled out for the exclusion."

"Are the above numbers valid for all parts of the body in all exposure conditions over the time averaging period of the exposure? They (the basic limits) were derived in the manner you describe in body reasonance conditions i.e. coherent exposure over the whole body length of a human. Could the limit values of SAR be increased for partial body exposure? Yes, but we do not have the data to make this decision. In the near field of a source, clearly the limit value will depend on frequency (depth of penetration), organ blood supply and tolerance of that organism to sustain a certain rate of temperature increase during the time averaging period and the environmental conditions. If you have to deal with possible pathologies of organs then matters become even more complicated, because you are dealing not only with heat physiology, but also with general pathology, whose books are much thicker than those on physiology.

Table 1

Radiofrequency Radiation Level at 6" at the Face in uW/cm2

(One Smart Meter, Four Meters)

One Meter	**Table A1**	**Table A2**	**Table A3**	**Table A4**
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection*	2000% Reflection*
1%	2.1 uW/cm2	3.3	99	361
10%	21	33	989	3606
20%	42	65	1979	7212
30%	63	98	2968	10818
40%	83	131	3958	14424
50%	105	164	4947	18030
60%	105	196	5936	21636
70%	147	229	6926	25241
80%	168	262	7915	28847
90%	188	294	8904	32453
100%***	209	327	9894	36059

Four Meters**	**Table A5**	**Table A6**	**Table A7**	**Table A8**
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection*	2000% Reflection*
	15 uW/cm^2	24	712	2596
10%	151	236	7124	25963
20%	301	471	14247	51925
30%	452	707	21371	77888
40%	603	942	28494	103850
50%	754	1177	35618	129813
60%	904	1413	42741	155775
70%	1055	1648	49865	181738
80%	1206	1884	56988	207701
90%	1356	2119	64112	233663
100%***	1507	2355	71235	259626

This table shows RF power density for face reading a meter at 6" distance.

*Note: 1000-2000% reflection based on Vermeeren et al, 2010; Christ et al, 2010; Hondou, 2002.
**More than 4 meters placed together do not appreciably increase the exposure to one reference point, such as a crib or bed. However, multiple meters can increase the square footage of space similarly affected.
***Continuous exposure is required in calculations of time-weighted average radiofrequency exposure for uncontrolled public access by FCC OET 65 (p. 15).

Table 2

Radiofrequency Radiation Level at 6" at the Face in uW/cm2

(One Collector, 1 Collector + 3 Smart Meters)

One Collector	**Table A9**	**Table A10**	**Table A11**	**Table A12**
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection*	2000% Reflection*
1%	6 uW/cm2	10	296	1078
10%	63	98	958	10780
20%	125	196	5916	21561
30%	188	293	8874	32341
40%	250	391	11832	43121
50%	313	489	14789	53902
60%	376	587	17747	64682
70%	438	685	20705	75462
80%	501	782	23663	86243
90%	563	880	26621	97023
100%***	626	978	29579	107803

One **C + 3 SM**	**Table A13**	**Table A14**	**Table A15**	**Table A16**
Duty Cycle	60% Reflection	100% Reflectio	1000% Reflection*	2000% Reflection*
1%	19	29	890	3242
10%	188	294	8895	32420
20%	376	588	17990	64839
30%	565	882	26686	97259
40%	753	1176	35581	129678
50%	941	1470	43700	162098
60%	1129	1764	53371	194517
70%	1317	2058	62266	226937
80%	1506	2352	71161	259356
90%	1694	2647	80056	291776
100%***	1882	2941	88952	324195

This table shows RF power density for face reading a meter at 6" distance.

*Note: 1000-2000% reflection based on Vermeeren et al, 2010; Christ et al, 2010; Hondou, 2002.
**More than 4 meters placed together do not appreciably increase the exposure to one reference point, such as a crib or bed. However, multiple meters can increase the square footage of space similarly affected.
***Continuous exposure is required in calculations of time-weighted average radiofrequency exposure for uncontrolled public access by FCC OET 65 (p. 15).

Table 3

Radiofrequency Radiation Level at 11" in the Nursery in uW/cm2

(One Smart Meter, Four Meters)

One Meter Duty Cycle	Table A17 60% Reflection	Table A18 100% Reflection	Table A19 1000% Reflection*	Table A20 2000% Reflection*
1%	1.4	2.2	66	241
5%	7	11	331	1227
10%	14	21.9	662	2414
20%	28	43.8	1324	4828
30%	42	65.7	1986	7242
40%	56.1	87.6	2649	9655
50%	70.1	109	3312	12069
60%	84.1	131	3974	14483
70%	98.1	153	4636	16897
80%	112	175	5299	19311
90%	126	197	5961	21175
100%***	140	218	6623	24139

Four** Meters Duty Cycle	Table A21 60% Reflection	Table A22 100% Reflection	Table A23 1000% Reflection*	Table A24 2000% Reflection*
1%	4.9	7.5	227	828
5%	24	38	1137	4142
10%	48	75	2273	8284
20%	96	150	4546	16569
30%	144	225	6819	24853
40%	192	301	9092	33137
50%	240	376	11365	41421
60%	289	451	13638	49705
70%	337	526	15911	57990
80%	385	601	18184	66274
90%	433	676	20457	74558
100%***	481	751	22730	82843

This table shows RF power density for readings at 11" in the crib.

*Note: 1000-2000% reflection based on Vermeeren et al, 2010; Christ et al, 2010; Hondou, 2002.
**More than 4 meters placed together do not appreciably increase the exposure to one reference point, such as a crib or bed. However, multiple meters can increase the square footage of space similarly affected.
***Continuous exposure is required in calculations of time-weighted average radiofrequency exposure for uncontrolled public access by FCC OET 65 (p. 15).

Table 4

Radiofrequency Radiation Level at 11" in the Nursery in uW/cm2

(One Collector/1C + 3 Smart Meters)

One Collector Duty Cycle	**Table A25** 60% Reflection	**Table A26** 100% Reflection	**Table A27** 1000% Reflection*	**Table A28** 2000% Reflection*
1%	4.0 uW/cm^2	6.2	187	680
5%	19.7	30.8	933	3399
10%	39.5	61.7	1865	6798
20%	78.9	123	3730	13596
30%	118	185	5596	20394
40%	158	247	7461	27192
50%	197	308	9326	33990
60%	237	370	11191	40788
70%	276	432	13056	47586
80%	316	493	14922	54384
90%	355	555	16787	61182
100%***	395	617	18652	67980

One Collector + 3 Meters** Duty Cycle	**Table A29** 60% Reflection	**Table A30** 100% Reflection	**Table A31** 1000% Reflection*	**Table A32** 2000% Reflection*
1%	7.4 uW/cm^2	11.5	348	1267
5%	36.8	57.5	1738	6334
10%	73.5	115	3476	12668
20%	147	230	6952	25337
30%	221	345	10428	38005
40%	294	460	13904	50674
50%	368	575	17380	63342
60%	441	689	20855	76010
70%	515	804	24331	88679
80%	588	919	27807	101347
90%	662	1034	31283	114015
100%***	735	1149	34759	126684

This table shows RF power density for readings at 11" in the crib.

*Note: 1000-2000% reflection based on Vermeeren et al, 2010; Christ et al, 2010; Hondou, 2002.

**More than 4 meters placed together do not appreciably increase the exposure to one reference point, such as a crib or bed. However, multiple meters can increase the square footage of space similarly affected.

***Continuous exposure is required in calculations of time-weighted average radiofrequency exposure for uncontrolled public access by FCC OET 65 (p. 15).

Table 5

Radiofrequency Radiation Level at 28" in the Kitchen in uW/cm2

(One Smart Meter, Four Meters)

One Meter Duty Cycle	**Table A33** 60% Reflection	**Table A34** 100% Reflection	**Table A35** 1000% Reflection*	**Table A36** 2000% Reflection*
1%	0.2	0.3	10.2	37.3
5%	1.1	1.7	51.1	186
10%	2.2	3.4	102	373
20%	4.3	6.8	204	745
30%	6.5	10.1	307	1118
40%	8.7	13.5	409	1490
50%	10.8	16.9	511	1863
60%	13	20.3	613	2235
70%	15.1	23.7	716	2608
80%	17.3	27	818	2980
90%	19.5	30.4	920	3353
100%***	21.6	33.8	1022	3726

Four Meters** Duty Cycle	**Table A37** 60% Reflection	**Table A38** 100% Reflection	**Table A39** 1000% Reflection*	**Table A40** 2000% Reflection*
1%	0.6	0.9	26	94.6
5%	2.8	4.3	129	473
10%	5.5	8.6	260	946
20%	11	17.2	519	1892
30%	16.5	25.7	779	2837
40%	22	34.3	1038	3783
50%	27.5	42.9	1298	4729
60%	32.9	51.5	1557	5675
70%	38.4	60.1	1817	6621
80%	43.9	68.6	2076	7566
90%	49.4	77.2	2336	8512
100%***	54.9	85.8	2595	9458

This table shows RF power density for readings at 28" in the kitchen work space.

*Note: 1000-2000% reflection based on Vermeeren et al, 2010; Christ et al, 2010; Hondou, 2002.
**More than 4 meters placed together do not appreciably increase the exposure to one reference point, such as a crib or bed. However, multiple meters can increase the square footage of space similarly affected.
***Continuous exposure is required in calculations of time-weighted average radiofrequency exposure for uncontrolled public access by FCC OET 65 (p. 15).

Table 6

Radiofrequency Radiation Level at 28" in the Kitchen in uW/cm2

(One Collector/1C + 3 Smart Meters)

One Collector Duty Cycle	**Table A41** 60% Reflection	**Table A42** 100% Reflection	**Table A43** 1000% Reflection*	**Table A44** 2000% Reflection*
1%	0.6 uW/cm^2	1	28.8	105
5%	3.1	4.8	144	525
10%	6.1	9.5	288	1049
20%	12.2	19	576	2098
30%	18.3	28.6	864	3148
40%	24.4	38.1	1152	4197
50%	30.5	47.6	1439	5246
60%	36.5	57.1	1727	6295
70%	42.6	66.6	2015	7344
80%	48.7	75.1	2303	8393
90%	54.8	85.7	2591	9243
100%***	60.9	95.2	2879	10492

One Collector + 3 Meters** Duty Cycle	**Table A45** 60% Reflection	**Table A46** 100% Reflection	**Table A47** 1000% Reflection*	**Table A48** 2000% Reflection*
1%	0.9 uW/cm^2	1.5	45	162
5%	4.7	7.4	223	811
10%	9.4	14.7	445	1622
20%	18.8	29.4	890	3245
30%	28.3	44.2	1336	4867
40%	37.7	58.9	1781	6490
50%	47.1	73.6	2226	8112
60%	56.5	88.3	2671	9734
70%	65.9	103	3116	11357
80%	75.4	118	3561	12979
90%	84.8	132	4006	14602
100%***	94.2	147	4452	16224

This table shows RF power density for readings at 28" in the kitchen work space.

*Note: 1000-2000% reflection based on Vermeeren et al, 2010; Christ et al, 2010; Hondou, 2002.
**More than 4 meters placed together do not appreciably increase the exposure to one reference point, such as a crib or bed. However, multiple meters can increase the square footage of space similarly affected.
***Continuous exposure is required in calculations of time-weighted average radiofrequency exposure for uncontrolled public access by FCC OET 65 (p. 15).

TABLE 7

DISTANCE AT WHICH FCC TWA SAFETY LIMIT IS EXCEEDED (in inches)
(FCC limit is 655 uW/cm^2 in smart meters)

One Smart Meter	**Table A1**	**Table A2**	**Table A3**	**Table A4**
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection*	2000% Reflection*
1%	0.5”	0.6”	3.5”	6.68”
10%	1.6”	2.0”	11.1 ”	21.1”
20%	2.3”	2.8”	15.6”	29.9”
30%	2.8”	3.5”	19.2”	36.6”
40%	3.2”	4.0”	22.1”	42.2”
50 %	3.6”	4.5”	24.7”	47.3”
60%	3.9”	4.9”	27.1”	51.7”
70%	4.3”	5.3”	29.3”	55.9”
80%	4.6”	5.7”	31.3”	59.8”
90%	4.8”	6.0”	33.2”	63.4”
100%***	5.1”	6.4”	35.0”	66.8”

Four Meters**	**Table A5**	**Table A6**	**Table A7**	**Table A8**
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection*	2000% Reflection*
1%	1.44”	1.8”	9.4”	18.7”
10%	3.42”	4.8’	31.2”	59.7”
20%	5.70”	7.47”	44.2”	84.0”
30%	7.29”	9.39”	54.1”	103.4”
40%	8.6”	11.0”	62.5”	119.5”
50 %	9.73”	12.4”	70”	133.6”
60%	10.7”	13.6”	76.6”	146.3”
70%	11.7”	14.8”	82.2”	158.0”
80%	12”	15.8”	88.4”	169.0”
90%	13”	16.8”	93.8”	179.3”
100%***	14”	17.7”	98.9”	188.9”

*Note: 1000-2000% reflection based on Vermeeren et al, 2010; Christ et al, 2010; Hondou, 2002.
**More than 4 meters placed together do not appreciably increase the exposure to one reference point, such as a crib or bed. However, multiple meters can increase the square footage of space similarly affected.
***Continuous exposure is required in calculations of time-weighted average radiofrequency exposure for uncontrolled public access by FCC OET 65 (p. 15).

TABLE 8

DISTANCE AT WHICH FCC TWA SAFETY LIMIT IS EXCEEDED FOR COLLECTOR METER (in inches)
(FCC limit is 571 uW/cm^2 or 624 uW/cm^2 for collector+ 3 SM)

FCC Limit=571 uW/cm^2 for collector meter

One Meter (1 collector)	**Table A9**	**Table A10**	**Table A11**	**Table A12**
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection*	2000% Reflection*
1%	0.9”	1.2”	6.5”	12.3”
10%	3.0”	3.7”	20.4”	39.0”
20%	4.2”	5.2”	28.9”	55.1”
30%	5.1”	6.4”	35.3”	67.5”
40%	5.9”	7.4”	40.8”	77.9”
50 %	6.6”	8.3”	45.6”	87.1”
60%	7.3”	9.1”	50.0”	95.4”
70%	7.9”	9.8”	54.0”	103”
80%	8.4”	10.5”	57.7”	110”
90%	8.9”	11.1”	61.2”	116”
100%***	9.4”	11.7”	64.5”	123”

FCC Limit = 624 uW/cm^2 for collector meter plus 3 smart meters

One Collector + 3 Smart Meters**	**Table A13**	**Table A14**	**Table A15**	**Table A16**
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection*	2000% Reflection*
1%	1.6”	2.1”	10.9”	21.3
10%	4.2”	5.6”	35.6”	68.1”
20%	6.7”	8.7”	50.4”	96.3”
30%	8.5”	10.8”	61.7”	118”
40%	9.9”	12.6”	71.3”	136”
50 %	11.2”	14.2”	79.7”	152”
60%	12.4”	15.6”	87.4”	167”
70%	13.4”	16.9”	94.4”	180”
80%	14.4”	18.1”	101”	193”
90%	15.3”	19.2”	107”	204”
100%***	16.1”	20.3”	113”	215”

*Note: 1000-2000% reflection based on Vermeeren et al, 2010; Christ et al, 2010; Hondou, 2002.
**More than 4 meters placed together do not appreciably increase the exposure to one reference point, such as a crib or bed. However, multiple meters can increase the square footage of space similarly affected.

***Continuous exposure is required in calculations of time-weighted average radiofrequency exposure for uncontrolled public access by FCC OET 65 (p. 15)

TABLE 9

PEAK POWER LIMIT
(Distance at which 4000 uW/cm2* FCC peak limit is exceeded in inches)**

	60% Reflection	100% Reflection	1000% Reflection*	2000% Reflection*
One Smart Meter	2”	2.6”	14.2”	27”
Four Smart Meters	4.1”	5.2”	28.3”	54”
One Collector Meter	4”	4.5”	24”	46.7”
One Collector + 3 SM	5.0”	6.3”	34.6”	66.1”

*Note: 1000-2000% reflection based on Vermeeren et al, 2010; Christ et al, 2010; Hondou, 2002.

**More than 4 meters placed together do not appreciably increase the exposure to one reference point, such as a crib or bed. However, multiple meters can increase the square footage of space similarly affected.

*** FCC OET 65 and ANSI/IEEE C95.1-1992, 1999 specify that 4000 uW/cm2 public safety limit be applied for frequencies between 300 MHz and 6 GHz (6000 MHz) for peak power exposure.

Table 10

Potential FCC Violations of TWA 655 uW/cm2 - Face at 6"

(One Smart Meter, Four Meters)

One Meter	Table A1	Table A2	Table A3	Table A4
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	2.1 uW/cm2	3.3	99	361
10%	21	33	989	3606
20%	42	65	1979	7212
30%	63	98	2968	10818
40%	83	131	3958	14424
50%	105	164	4947	18030
60%	105	196	5936	21636
70%	147	229	6926	25241
80%	168	262	7915	28847
90%	188	294	8904	32453
100%	209	327	9894	36059

Four Meters	Table A5	Table A6	Table A7	Table A8
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
	15 uW/cm^2	24	712	2596
10%	151	236	7124	25963
20%	301	471	14247	51925
30%	452	707	21371	77888
40%	603	942	28494	103850
50%	754	1177	35618	129813
60%	904	1413	42741	155775
70%	1055	1648	49865	181738
80%	1206	1884	56988	207701
90%	1356	2119	64112	233663
100%	1507	2355	71235	259626

This table shows RF power density for face reading a meter at 6" distance.

Exceeds 655 uW/cm2 at 6" at the face

Table 11

Potential FCC Violations of TWA 571/624 uW/cm2- Face at 6"

(One Collector, 1 Collector + 3 Smart Meters)

One Collector Duty Cycle **571 limit**	**Table A9** 60% Reflection	**Table A10** 100% Reflection	**Table A11** 1000% Reflection	**Table A12** 2000% Reflection
1%	6 uW/cm2	9	279	1015
10%	59	92	2786	10152
20%	118	184	5571	20305
30%	177	276	8357	30457
40%	236	368	11142	40610
50%	295	460	13928	50762
60%	354	553	16713	60914
70%	413	645	19449	71067
80%	471	737	22285	81219
90%	530	829	25070	91372
100%	589	921	27856	101524

One C + 3 SM Duty Cycle **624 limit**	**Table A13** 60% Reflection	**Table A14** 100% Reflectio	**Table A15** 1000% Reflection	**Table A16** 2000% Reflection
1%	18	29	874	3185
10%	185	289	8740	31854
20%	370	578	17480	63709
30%	555	867	26220	95563
40%	740	1156	34960	127418
50%	925	1445	43700	159272
60%	1109	1734	52441	191126
70%	1294	2023	61181	222981
80%	1479	2311	69921	254835
90%	1664	2600	78661	286690
100%	1849	2889	87401	318544

This table shows RF power density for face reading a meter at 6" distance.

Exceeds 571 or 624 uW/cm2 at 6" at the face.

Table 12

Potential FCC Violations of 655 uW/cm2 TWA Safety Limit

Nursery at 11"

(One Smart Meter, Four Meters)

One Meter Duty Cycle	Table A17 60% Reflection	Table A18 100% Reflection	Table A19 1000% Reflection	Table A20 2000% Reflection
1%	1.4	2.2	66.2	241
5%	7	11	331	1227
10%	14	21.9	662	2414
20%	28	43.8	1324	4828
30%	42	65.7	1986	7242
40%	56.1	87.6	2649	9655
50%	70.1	109	3312	12069
60%	84.1	131	3974	14483
70%	98.1	153	4636	16897
80%	112	175	5299	19311
90%	126	197	5961	21175
100%	140	218	6623	24139

Four Meters Duty Cycle	Table A21 60% Reflection	Table A22 100% Reflection	Table A23 1000% Reflection	Tab;e A24 2000% Reflection
1%	4.9	7.5	227	828
5%	24	37.6	1137	4142
10%	48.1	75.1	2273	8284
20%	96.2	150	4546	16569
30%	144	225	6819	24853
40%	192	301	9092	33137
50%	240	376	11365	41421
60%	289	451	13638	49705
70%	337	526	15911	57990
80%	385	601	18184	66274
90%	433	676	20457	74558
100%	481	751	22730	82843

This table shows RF power density FCC violations at 11".

Exceeds 655 uW/cm2 FCC TWA Safety Limit

Table 13

Potential FCC Violations of the 571/624 uW/cm2

TWA Safety Limit at 11" in the Nursery

(One Collector/1C + 3 Smart Meters)

One Collector Duty Cycle 571 limit	**Table A25** 60% Reflection	**TableA26** 100% Reflection	**Table A27** 1000% Reflection	**Table A28** 2000% Reflection
1%	4.0 uW/cm^2	6.2	187	680
5%	19.7	30.8	933	3399
10%	39.5	61.7	1865	6798
20%	78.9	123	3730	13596
30%	118	185	5596	20394
40%	158	247	7461	27192
50%	197	308	9326	33990
60%	237	370	11191	40788
70%	276	432	13056	47586
80%	316	493	14922	54384
90%	355	555	16787	61182
100%	395	617	18652	67980

One Collector + 3 Meters** Duty Cycle 624 limit	**Table A29** 60% Reflection	**Table A30** 100% Reflection	**Table A31** 1000% Reflection	**Table A32** 2000% Reflection
1%	7.4 uW/cm^2	11.5	348	1267
5%	36.8	57.5	1738	6334
10%	73.5	115	3476	12668
20%	147	230	6952	25337
30%	221	345	10428	38005
40%	294	460	13904	50674
50%	368	575	17380	63342
60%	441	689	20855	76010
70%	515	804	24331	88679
80%	588	919	27807	101347
90%	662	1034	31283	114015
100%	735	1149	34759	126684

This table shows RF power density FCC violations at 11"

Exceeds either 571 or 624 uW/cm2 FCC Limit

Table 14

Potential FCC Violations of the 655 uW/cm2 Safety Limit at 28" in the Kitchen

(One Smart Meter, Four Meters)

One Meter Duty Cycle	**Table A33** 60% Reflection	**Table A34** 100% Reflection	**TableA35** 1000% Reflection	**Table A36** 2000% Reflection
1%	0.2	0.3	10.2	37.3
5%	1.1	1.7	51.1	186
10%	2.2	3.4	102	373
20%	4.3	6.8	204	745
30%	6.5	10.1	307	1118
40%	8.7	13.5	409	1490
50%	10.8	16.9	511	1863
60%	13	20.3	613	2235
70%	15.1	23.7	716	2608
80%	17.3	27	818	2980
90%	19.5	30.4	920	3353
100%	21.6	33.8	1022	3726

Four Meters Duty Cycle	**Table A37** 60% Reflection	**Table A38** 100% Reflection	**Table A39** 1000% Reflection	**Table A40** 2000% Reflection
1%	0.6	0.9	26	94.6
5%	2.8	4.3	129	473
10%	5.5	8.6	260	946
20%	11	17.2	519	1892
30%	16.5	25.7	779	2837
40%	22	34.3	1038	3783
50%	27.5	42.9	1298	4729
60%	32.9	51.5	1557	5675
70%	38.4	60.1	1817	6621
80%	43.9	68.6	2076	7566
90%	49.4	77.2	2336	8512
100%	54.9	85.8	2595	9458

This table shows RF power density readings at 28" in the kitchen work space.

Exceeds 655 uW/cm2 FCC Limit

Table 15

Potential FCC Violations of 571/624 uW/cm2 FCC Limit at 28" in the Kitchen

(One Collector/1C + 3 Smart Meters)

One Collector Duty Cycle 571 limit	**Table A41** 60% Reflection	**Table A42** 100% Reflection	**Table A43** 1000% Reflection	**Table A44** 2000% Reflection
1%	0.6 uW/cm^2	1	28.8	105
5%	3.1	4.8	144	525
10%	6.1	9.5	288	1049
20%	12.2	19	576	2098
30%	18.3	28.6	864	3148
40%	24.4	38.1	1152	4197
50%	30.5	47.6	1439	5246
60%	36.5	57.1	1727	6295
70%	42.6	66.6	2015	7344
80%	48.7	75.1	2303	8393
90%	54.8	85.7	2591	9243
100%	60.9	95.2	2879	10492

One Collector + 3 Meters** Duty Cycle 624 limit	**Table A45** 60% Reflection	**Table A46** 100% Reflection	**Table A47** 1000% Reflection	**Table A48** 2000% Reflection
1%	0.9 uW/cm^2	1.5	45	162
5%	4.7	7.4	223	811
10%	9.4	14.7	445	1622
20%	18.8	29.4	890	3245
30%	28.3	44.2	1336	4867
40%	37.7	58.9	1781	6490
50%	47.1	73.6	2226	8112
60%	56.5	88.3	2671	9734
70%	65.9	103	3116	11357
80%	75.4	118	3561	12979
90%	84.8	132	4006	14602
100%	94.2	147	4452	16224

This table shows RF power density readings at 28" in the kitchen work space.

Exceeds 571/624 uW/cm2 FCC Limit

Table 16

Potential FCC Violations of Peak Power Limit 4000 uW/cm2 at 3"

(One Smart Meter, Four Meters)

One Meter	**Table A1**	**Table A2**	**Table A3**	**Table A4**
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	19	29	890	3245
10%	188	294	8904	32453
20%	377	589	17809	64906
30%	565	883	26713	97360
40%	754	1177	35618	129813
50%	942	1472	44522	162266
60%	1130	1766	53426	194719
70%	1319	2061	62331	227172
80%	1507	2355	71235	259626
90%	1696	2649	80140	292079
100%	1884	2944	89044	324532

Four Meters	**Table A5**	**Table A6**	**Table A7**	**Table A8**
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	75	118	3562	12981
10%	754	1177	35618	129813
20%	1507	2355	71235	259626
30%	2261	3532	106853	389438
40%	3014	4710	142470	519251
50%	3768	5887	178088	649064
60%	4521	7065	213705	778877
70%	5275	8242	249323	908690
80%	6029	9420	284941	1038503
90%	6782	10597	320558	1168315
100%	7536	11774	356176	1298128

This table shows RF power density at 3" distance at surface of meter

Exceeds 4000 uW/cm2 at 3" from antenna radiation center at face of meter.

Table 17

Potential FCC Violations of Peak Power Limit 4000 uW/cm2 at 3"

(One Collector, 1 Collector + 3 Smart Meters)

One Collector	**Table A9**	**Table A10**	**Table A11**	**Table A12**
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
571 limit				
1%	53	83	2507	9137
10%	530	829	25070	91372
20%	1061	1658	50140	182743
30%	1591	2486	75211	274115
40%	2122	3315	100281	365486
50%	2652	4144	125351	456858
60%	3182	4973	150421	548229
70%	3713	5801	175491	639601
80%	4243	6630	200562	730972
90%	4774	7459	225632	822344
100%	5304	8288	250702	913715

One C + 3 SM	**Table A13**	**Table A14**	**Table A15**	**Table A16**
Duty Cycle	60% Reflection	100% Reflectio	1000% Reflection	2000% Reflection
624 limit				
1%	92	144	4370	15927
10%	925	1445	43700	159272
20%	1849	2889	87401	318544
30%	2774	4334	131101	477816
40%	3698	5779	174802	637088
50%	4623	7223	218502	796360
60%	5547	8668	262203	955632
70%	6472	10113	305903	1114904
80%	7397	11557	349604	1274176
90%	8321	13002	393304	1433448
100%	9246	14446	437005	1592720

This table shows RF power density at 3" distance at surface of meter.

Exceeds 4000 uW/cm2 at 3" from antenna radiation center at face of meter.

Table 18

Radiofrequency Radiation Levels Associated with Inhibition of DNA Repair in Human Stem Cells at 11" in the Nursery

(One Smart Meter, Four Meters)

One Meter	**Table A17**	**Table A18**	**Table A19**	**Table A20**
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	1.4	2.2	66.2	241
5%	7	11	331	1227
10%	14	21.9	662	2414
20%	28	43.8	1324	4828
30%	42	65.7	1986	7242
40%	56.1	87.6	2649	9655
50%	70.1	109	3312	12069
60%	84.1	131	3974	14483
70%	98.1	153	4636	16897
80%	112	175	5299	19311
90%	126	197	5961	21175
100%	140	218	6623	24139

Four Meters	**Table A21**	**Table A22**	**Table A23**	**Table A24**
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	4.9	7.5	227	828
5%	24	37.6	1137	4142
10%	48.1	75.1	2273	8284
20%	96.2	150	4546	16569
30%	144	225	6819	24853
40%	192	301	9092	33137
50%	240	376	11365	41421
60%	289	451	13638	49705
70%	337	526	15911	57990
80%	385	601	18184	66274
90%	433	676	20457	74558
100%	481	751	22730	82843

Exceeds 0.037 W/Kg or ~92 uW/cm2

Table 19

Radiofrequency Radiation Level Associated with Inhibition of DNA Repair in Human Stem Cells at 11" in the Nursery
(One Collector / 1C + 3 Smart Meters)

One Collector	Table A25	Table A26	Table A27	Table A28
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	4.0 uW/cm^2	6.2	187	680
5%	19.7	30.8	933	3399
10%	39.5	61.7	1865	6798
20%	78.9	123	3730	13596
30%	118	185	5596	20394
40%	158	247	7461	27192
50%	197	308	9326	33990
60%	237	370	11191	40788
70%	276	432	13056	47586
80%	316	493	14922	54384
90%	355	555	16787	61182
100%	395	617	18652	67980

One C+ 3 SM	Table A29	Table A30	Table A31	Table A32
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	7.4 uW/cm^2	11.5	348	1267
5%	36.8	57.5	1738	6334
10%	73.5	115	3476	12668
20%	147	230	6952	25337
30%	221	345	10428	38005
40%	294	460	13904	50674
50%	368	575	17380	63342
60%	441	689	20855	76010
70%	515	804	24331	88679
80%	588	919	27807	101347
90%	662	1034	31283	114015
100%	735	1149	34759	126684

Exceeds 0.037 W/Kg or ~92 uW/cm2

Table 20

Radiofrequency Radiation Level Associated with Pathological Leakage of the Blood-brain Barrier at 0.4-8 uW/cm2 at 11" in the Nursery

(One Smart Meter, Four Meters)

One Meter	**Table A17**	**Table A18**	**Table A19**	**Table A20**
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	1.4	2.2	66.2	241
5%	7	11	331	1227
10%	14	21.9	662	2414
20%	28	43.8	1324	4828
30%	42	65.7	1986	7242
40%	56.1	87.6	2649	9655
50%	70.1	109	3312	12069
60%	84.1	131	3974	14483
70%	98.1	153	4636	16897
80%	112	175	5299	19311
90%	126	197	5961	21175
100%	140	218	6623	24139
Four Meters	**Table A21**	**Table A22**	**Table A23**	**Table A24**
	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
	4.9	7.5	227	828
	24	37.6	1137	4142
	48.1	75.1	2273	8284
	96.2	150	4546	16569
	144	225	6819	24853
	192	301	9092	33137
	240	376	11365	41421
	289	451	13638	49705
	337	526	15911	57990
	385	601	18184	66274
	433	676	20457	74558
	481	751	22730	82843

Exceeds between 0.4-8	Exceeds 8 uW/cm2

Table 21

Radiofrequency Radiation Level Associated with Pathological Leakage of the Blood-brain Barrier at 0.4 - 8 uW/cm2

(One Collector/1C + 3 Smart Meters)

One Collector Duty Cycle	**Table 25** 60% Reflection	**Table A26** 100% Reflection	**Table A27** 1000% Reflection	**Table A28** 2000% Reflection
1%	4.0 uW/cm^2	6.2	187	680
5%	19.7	30.8	933	3399
10%	39.5	61.7	1865	6798
20%	78.9	123	3730	13596
30%	118	185	5596	20394
40%	158	247	7461	27192
50%	197	308	9326	33990
60%	237	370	11191	40788
70%	276	432	13056	47586
80%	316	493	14922	54384
90%	355	555	16787	61182
100%	395	617	18652	67980

One Collector + 3 Meters** Duty Cycle	**Table A29** 60% Reflection	**Table A30** 100% Reflection	**Table A31** 1000% Reflection	**Table A32** 2000% Reflection
1%	7.4 uW/cm^2	11.5	348	1267
5%	36.8	57.5	1738	6334
10%	73.5	115	3476	12668
20%	147	230	6952	25337
30%	221	345	10428	38005
40%	294	460	13904	50674
50%	368	575	17380	63342
60%	441	689	20855	76010
70%	515	804	24331	88679
80%	588	919	27807	101347
90%	662	1034	31283	114015
100%	735	1149	34759	126684

Exceeds between 0.4-8	Exceeds 8 uW/cm2

Table 22 Radiofrequency Radiation Levels Associated with Adverse Neurological Symptoms, Cardiac Problems and Increased Cancer Risk (chronic exposure above 0.05- 0.1 uW/cm2) Nursery at 11" One Meter and Four Meters

As reported in Khurana et al, 2010 in the International Journal of Environmental Occupational Health 16:263-267; Kundi and Hutter, 2009, Pathophysiology 16: 123-135 and the BioInitiative Report, 2007, Chapters 1 and 17.

One Meter Duty Cycle	**Table A17** 60% Reflection	**Table A18** 100% Reflection	**Table A19** 1000% Reflection	**Table A20** 2000% Reflection
1%	1.4	2.2	66.2	241
5%	7	11	331	1227
10%	14	21.9	662	2414
20%	28	43.8	1324	4828
30%	42	65.7	1986	7242
40%	56.1	87.6	2649	9655
50%	70.1	109	3312	12069
60%	84.1	131	3974	14483
70%	98.1	153	4636	16897
80%	112	175	5299	19311
90%	126	197	5961	21175
100%	140	218	6623	24139

Four Meters Duty Cycle	**Table A21** 60% Reflection	**Table A22** 100% Reflection	**Table A23** 1000% Reflection	**Table A24** 2000% Reflection
1%	4.9	7.5	227	828
5%	24	37.6	1137	4142
10%	48.1	75.1	2273	8284
20%	96.2	150	4546	16569
30%	144	225	6819	24853
40%	192	301	9092	33137
50%	240	376	11365	41421
60%	289	451	13638	49705
70%	337	526	15911	57990
80%	385	601	18184	66274
90%	433	676	20457	74558
100%	481	751	22730	82843

Exceeds 0.1 uW/cm2

All exposure levels exceed those identified in Khurana et al, 2010; Kundi and Hutter, 2009 and the BioInitiative Report (2007) to be associated with increased risk of adverse neurological symptoms (headache, sleep disruption, restlessness, tremor, cognitive impairment tinnitus), increased cancer risk or heart problems, arrythmias, altered heart rhythm, palpitations. These effects are reported in studies of populations living at distances < 500 meters from base stations, and at levels at or over 0.05-0.1 uW/cm2, but not at RF levels below chronic RF exposure levels of 0.05 - 0.1 uW/cm2 in healthy populations.

Table 23 Radiofrequency Radiation Levels Associated with Adverse Neurological Symptoms, Cardiac Problems and Increased Cancer Risk (chronic exposure above 0.05- 0.1 uW/cm2) Nursery at 11" One Meter and Four Meters

As reported in Khurana et al, 2010 in the International Journal of Environmental Occupational Health 16:263-267;
Kundi and Hutter, 2009, Pathophysiology 16: 123-135 and the BioInitiative Report, 2007, Chapters 1 and 17.

One Collector				
	Table A33	**Table A34**	**Table A35**	**Table A36**
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	4	6.2	187	680
5%	20	30.8	933	3399
10%	40	61.7	1865	6798
20%	79	123	3730	13596
30%	118	185	5596	20394
40%	158	247	7461	27192
50%	197	308	9326	33990
60%	237	370	11191	40788
70%	276	432	13056	47586
80%	316	493	14922	54384
90%	355	555	16787	61182
100%	395	617	18652	67980
1C + 3 SM	**Table A37**	**Table A38**	**Table A39**	**Table A40**
Duty Cycle	60% Reflection	100% Reflection	100% Reflection	2000% Reflection
1%	7.4	11.5	348	1267
5%	36.8	57.5	1738	6334
10%	73.5	115	3476	12668
20%	147	230	6952	25337
30%	221	345	10428	38005
40%	294	460	13904	50674
50%	368	575	17380	63342
60%	441	689	20855	76010
70%	515	804	24331	88679
80%	588	919	27807	101347
90%	662	1034	31283	114015
100%	735	1149	34759	126684

Exceeds 0.1 uW/cm2

All exposure levels exceed those identified in Khurana et al, 2010; Kundi and Hutter, 2009 and the BioInitiative Report (2007) to be associated with increased risk of adverse neurological symptoms (headache, sleep disruption, restlessness, tremor, cognitive impairment tinnitus), increased cancer risk or heart problems, arrythmias, altered heart rhythm, palpitations. These effects are reported in studies of populations living at distances < 500 meters from base stations, and at levels at or over 0.05-0.1 uW/cm2, but not at RF levels below chronic RF exposure levels of 0.05 - 0.1 uW/cm2 in healthy populations.

Table 24

Radiofrequency Radiation Levels Associated with Inhibition of DNA Repair in Human Stem Cells at 28" Kitchen Example

(One Smart Meter, Four Meters)

One Meter	Table A33	Table A34	Table A35	Table A36
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	0.2	0.3	10.2	37.3
5%	1.1	1.7	51.1	186
10%	2.2	3.4	102	373
20%	4.3	6.8	204	745
30%	6.5	10.1	307	1118
40%	8.7	13.5	409	1490
50%	10.8	16.9	511	1863
60%	13	20.3	613	2235
70%	15.1	23.7	716	2608
80%	17.3	27	818	2980
90%	19.5	30.4	920	3353
100%	21.6	33.8	1022	3726

Four Meters	Table A37	Table A38	Table A39	Table A40
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	0.6	0.9	26	94.6
5%	2.8	4.3	129	473
10%	5.5	8.6	260	946
20%	11	17.2	519	1892
30%	16.5	25.7	779	2837
40%	22	34.3	1038	3783
50%	27.5	42.9	1298	4729
60%	32.9	51.5	1557	5675
70%	38.4	60.1	1817	6621
80%	43.9	68.6	2076	7566
90%	49.4	77.2	2336	8512
100%	54.9	85.8	2595	9458

Exceeds 0.037 W/Kg or ~92 uW/cm2

Table 25

Radiofrequency Radiation Levels Associated with Inhibition of DNA Repair in Human Stem Cells at 28" in Kitchen

(One Collector / 1C + 3 Smart Meters)

One Collector	**Table A41**	**Table A42**	**Table A43**	**Table A44**
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	0.6 uW/cm^2	1	28.8	105
5%	3.1	4.8	144	525
10%	6.1	9.5	288	1049
20%	12.2	19	576	2098
30%	18.3	28.6	864	3148
40%	24.4	38.1	1152	4197
50%	30.5	47.6	1439	5246
60%	36.5	57.1	1727	6295
70%	42.6	66.6	2015	7344
80%	48.7	75.1	2303	8393
90%	54.8	85.7	2591	9243
100%	60.9	95.2	2879	10492

One Collector + 3 SM	**Table A45**	**Table A46**	**Table A47**	**Table A48**
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	0.9 uW/cm^2	1.5	45	162
5%	4.7	7.4	223	811
10%	9.4	14.7	445	1622
20%	18.8	29.4	890	3245
30%	28.3	44.2	1336	4867
40%	37.7	58.9	1781	6490
50%	47.1	73.6	2226	8112
60%	56.5	88.3	2671	9734
70%	65.9	103	3116	11357
80%	75.4	118	3561	12979
90%	84.8	132	4006	14602
100%	94.2	147	4452	16224

Exceeds 0.037 W/Kg or ~92 uW/cm2

Table 26

Radiofrequency Radiation Levels Associated with Pathological Leakage of the Blood-brain Barrier at 0.4 - 8 uW/cm2 at 28" in Kitchen

(One Smart Meter, Four Meters)

One Meter	**Table A33**	**Table A34**	**Table A35**	**Table A36**
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	0.2	0.3	10.2	37.3
5%	1.1	1.7	51.1	186
10%	2.2	3.4	102	373
20%	4.3	6.8	204	745
30%	6.5	10.1	307	1118
40%	8.7	13.5	409	1490
50%	10.8	16.9	511	1863
60%	13	20.3	613	2235
70%	15.1	23.7	716	2608
80%	17.3	27	818	2980
90%	19.5	30.4	920	3353
100%	21.6	33.8	1022	3726

Four Meters	**Table A37**	**Table A38**	**Table A39**	**Table A40**
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	0.6	0.9	26	94.6
5%	2.8	4.3	129	473
10%	5.5	8.6	260	946
20%	11	17.2	519	1892
30%	16.5	25.7	779	2837
40%	22	34.3	1038	3783
50%	27.5	42.9	1298	4729
60%	32.9	51.5	1557	5675
70%	38.4	60.1	1817	6621
80%	43.9	68.6	2076	7566
90%	49.4	77.2	2336	8512
100%	54.9	85.8	2595	9458

Exceeds 8 uW/cm2 | Exceeds between 0.4 and 8 uW/cm2

Table 27

Radiofrequency Radiation Levels Associated with Pathological Leakage of the Blood-brain Barrier at 0.4 - 8 uW/cm2 at 28" in Kitchen

One Collector/1C + 3 Smart Meters

One Collector	**Table A41**	**Table A42**	**Table A43**	**Table A44**
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	0.6 uW/cm^2	1	28.8	105
5%	3.1	4.8	144	525
10%	6.1	9.5	288	1049
20%	12.2	19	576	2098
30%	18.3	28.6	864	3148
40%	24.4	38.1	1152	4197
50%	30.5	47.6	1439	5246
60%	36.5	57.1	1727	6295
70%	42.6	66.6	2015	7344
80%	48.7	75.1	2303	8393
90%	54.8	85.7	2591	9243
100%	60.9	95.2	2879	10492
One Collector + 3 SM	**Table A45**	**Table A46**	**Table A47**	**Table A48**
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	0.9 uW/cm^2	1.5	45	162
5%	4.7	7.4	223	811
10%	9.4	14.7	445	1622
20%	18.8	29.4	890	3245
30%	28.3	44.2	1336	4867
40%	37.7	58.9	1781	6490
50%	47.1	73.6	2226	8112
60%	56.5	88.3	2671	9734
70%	65.9	103	3116	11357
80%	75.4	118	3561	12979
90%	84.8	132	4006	14602
100%	94.2	147	4452	16224

Exceeds 8 uW/cm2 | Exceeds between 0.4 and 8 uW/cm2

Table 28 Radiofrequency Radiation Levels Associated with Adverse Neurological Symptoms, Cardiac Problems and Increased Cancer Risk (chronic exposure above 0.05- 0.1 uW/cm2) Kitchen at 28" One Meter and Four Meters

As reported in Khurana et al, 2010 in the International Journal of Environmental Occupational Health 16:263-267; Kundi and Hutter, 2009, Pathophysiology 16: 123-135 and the BioInitiative Report, 2007, Chapters 1 and 17.

One Meter	**Table A33**	**Table A34**	**Table A35**	**Table A36**
Duty Cycle	60% Reflectio	100% Reflection	1000% Reflection	2000% Reflection
1%	0.2	0.3	10.2	37.3
5%	1.1	1.7	51.1	186
10%	2.2	3.4	102	373
20%	4.3	6.8	204	745
30%	6.5	10.1	307	1118
40%	8.7	13.5	409	1490
50%	10.8	16.9	511	1863
60%	13	20.3	613	2235
70%	15.1	23.7	716	2608
80%	17.3	27	818	2980
90%	19.5	30.4	920	3353
100%	21.6	33.8	1022	3726

Four Meters	**Table A37**	**Table A38**	**Table A39**	**Table A40**
Duty Cycle	60% Reflection	100% Reflection	100% Reflection	2000% Reflection
1%	0.6	0.9	26	94.6
5%	2.8	4.3	129	473
10%	5.5	8.6	260	946
20%	11	17.2	519	1892
30%	16.5	25.7	779	2837
40%	22	34.3	1038	3783
50%	27.5	42.9	1298	4729
60%	32.9	51.5	1557	5675
70%	38.4	60.1	1817	6621
80%	43.9	68.6	2076	7566
90%	49.4	77.2	2336	8512
100%	54.9	85.8	2595	9458

Exceeds 0.1 uW/cm2

All exposure levels exceed those identified in Khurana et al, 2010; Kundi and Hutter, 2009 and the BioInitiative Report (2007) to be associated with increased risk of adverse neurological symptoms (headache, sleep disruption, restlessness, tremor, cognitive impairment tinnitus), increased cancer risk or heart problems, arrythmias, altered heart rhythm, palpitations. These effects are reported in studies of populations living at distances < 500 meters from base stations, and at levels at or over 0.05-0.1 uW/cm2, but not at RF levels below chronic RF exposure levels of 0.05 - 0.1 uW/cm2 in healthy populations.

Table 29 Radiofrequency Radiation Levels Associated with Adverse Neurological Symptoms, Cardiac Problems and Increased Cancer Risk (chronic exposure above 0.05- 0.1 uW/cm2) Kitchen at 28" One Collector, 1C + 3 Smart Meters

As reported in Khurana et al, 2010 in the International Journal of Environmental Occupational Health 16:263-267; Kundi and Hutter, 2009, Pathophysiology 16: 123-135 and the BioInitiative Report, 2007, Chapters 1 and 17.

One Collector	Table A41	Table A42	Table A43	Table A44
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	0.6	1	28.8	105
5%	3.1	4.8	144	525
10%	6.1	9.5	288	1049
20%	12.2	19	576	2098
30%	18.3	28.6	864	3148
40%	24.4	38.1	1152	4197
50%	30.5	47.6	1439	5246
60%	36.5	57.1	1727	6295
70%	42.6	66.6	2015	7344
80%	48.7	75.1	2303	8393
90%	54.8	85.7	2591	9243
100%	60.9	95.2	2879	10492

1C, 1C+3 SM	Table A45	Table A46	Table A47	Table A48
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	0.9	1.5	45	162
5%	4.7	7.4	223	811
10%	9.4	14.7	445	1622
20%	18.8	29.4	890	3245
30%	28.3	44.2	1336	4867
40%	37.7	58.9	1781	6490
50%	47.1	73.6	2226	8112
60%	56.5	88.3	2671	9734
70%	65.9	103	3116	11357
80%	75.4	118	3561	12979
90%	84.8	132	4006	14602
100%	94.2	147	4452	16224

Exceeds 0.1 uW/cm2

All exposure levels exceed those identified in Khurana et al, 2010; Kundi and Hutter, 2009 and the BioInitiative Report (2007) to be associated with increased risk of adverse neurological symptoms (headache, sleep disruption, restlessness, tremor, cognitive impairment tinnitus), increased cancer risk or heart problems, arrythmias, altered heart rhythm, palpitations. These effects are reported in studies of populations living at distances < 500 meters from base stations, and at levels at or over 0.05-0.1 uW/cm2, but not at RF levels below chronic RF exposure levels of 0.05 - 0.1 uW/cm2 in healthy populations.

Table 30

Exceeds Medtronics Advisory Limit at 11"

(One Smart Meter, Four Meters)

One Meter	Table A17	Table A18	Table A19	Table A20
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	1.4	2.2	66.2	241
5%	7	11	331	1227
10%	14	21.9	662	2414
20%	28	43.8	1324	4828
30%	42	65.7	1986	7242
40%	56.1	87.6	2649	9655
50%	70.1	109	3312	12069
60%	84.1	131	3974	14483
70%	98.1	153	4636	16897
80%	112	175	5299	19311
90%	126	197	5961	21175
100%	140	218	6623	24139

Four Meters	Table A21	Table A22	Table A23	Tab;e A24
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	4.9	7.5	227	828
5%	24	37.6	1137	4142
10%	48.1	75.1	2273	8284
20%	96.2	150	4546	16569
30%	144	225	6819	24853
40%	192	301	9092	33137
50%	240	376	11365	41421
60%	289	451	13638	49705
70%	337	526	15911	57990
80%	385	601	18184	66274
90%	433	676	20457	74558
100%	481	751	22730	82843

Exceeds Medtronics SAR Advisory Limit

Table 31

Exceeds Medtronics Advisory Limit at 11"

(One Collector, 1C + 3 SM)

One Collector	**Table A25**	**TableA26**	**Table A27**	**Table A28**
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	4.0 uW/cm^2	6.2	187	680
5%	19.7	30.8	933	3399
10%	39.5	61.7	1865	6798
20%	78.9	123	3730	13596
30%	118	185	5596	20394
40%	158	247	7461	27192
50%	197	308	9326	33990
60%	237	370	11191	40788
70%	276	432	13056	47586
80%	316	493	14922	54384
90%	355	555	16787	61182
100%	395	617	18652	67980

One Collector + 3 Meters**	**Table A29**	**Table A30**	**Table A31**	**Table A32**
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	7.4 uW/cm^2	11.5	348	1267
5%	36.8	57.5	1738	6334
10%	73.5	115	3476	12668
20%	147	230	6952	25337
30%	221	345	10428	38005
40%	294	460	13904	50674
50%	368	575	17380	63342
60%	441	689	20855	76010
70%	515	804	24331	88679
80%	588	919	27807	101347
90%	662	1034	31283	114015
100%	735	1149	34759	126684

Exceeds Medtronics SAR Advisory Limit

Table 32

Distance to the BioInitiative Report Recommendation 0f 0.1 uW/cm2 (in feet)

(One Smart Meter, Four Meters)

One Meter	Table A1	Table A2	Table A3	Table A4
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	3.4’	28.0’	23.6’	45’
10%	10.9’	13.6’	74.5’	143'
20%	15.3’	19.2’	105’	201'
30%	18.8’	23.5’	129’	247'
40%	21.7’	27.1’	149’	285'
50%	24.3’	30.4’	167’	318'
60%	26.6’	33.2’	348’	348
70%	28.7’	35.8’	197’	376'
80%	30.7’	38.3’	211’	403'
90%	32.6’	40.6’	224’	428'
100%	34.3’	42.8’	256’	450'

Four Meters	Table A5	Table A6	Table A7	Table A8
Duty Cycle	60% Reflectio	100% Reflection	1000% Reflection	2000% Reflection
1%	9.7	12'	67'	128'
10%	30.7’	38.4’	211’	402'
20%	43.5’	54.2’	298’	570'
30%	53.2’	66.3’	365’	698'
40%	61.3’	76.8’	422’	805'
50%	68.5’	85.8’	471’	900'
60%	75.0’	94.0’	517’	985'
70%	81’	102’	558’	1065'
80%	87’	109’	598’	1140'
90%	92’	115’	632’	1210'
100%	97’	122’	667’	1275'

Exceeds the BioInitiative Recommendation of 0.1 uW/cm2 at this distance (in feet)

Table 33

Distance to the BioInitiative Report Recommendation Of 0.1 uW/cm2 (in feet)

(One Collector, 1C + 3 Smart Meters)

One Collector	**Table A9**	**Table A10**	**Table A11**	**Table A12**
Duty Cycle	60% Reflection	100% Reflection	1000% Reflection	2000% Reflection
1%	5.9’	7.25’	41'	78’
10%	18.6’	23.0’	129’	246’
20%	26.5’	32.5	182’	348’
30%	32.5’	39.8’	223’	426’
40%	37.5’	46.0’	258’	493’
50%	42.0’	51.3’	288’	550’
60%	46.0’	56.3’	603’	603'
70%	49.6’	60.8’	342’	650'
80%	53.0’	64.8’	365’	695'
90%	56.3’	68.8’	387’	739'
100%	59.2’	74.0’	407’	778'

1C + 3 Smart Meters	**Table A13**	**Table A14**	**Table A15**	**Table A16**
Duty Cycle	60% Reflectio	100% Reflection	1000% Reflection	2000% Reflection
1%	10.9’	13.6’	74.7’	142’
10%	34.3’	42.8’	236’	450’
20%	48.5’	60.5’	333’	673'
30%	58.5	74.3’	408’	780’
40%	68.5	85.6’	471’	900'
50%	76.5’	96.0’	526’	1005’
60%	84.0’	105’	577'	1100'
70%	90.7’	114’	625’	1190'
80%	97.0’	121’	666'	1160'
90%	103’	129’	707’	1275’
100%	108’	136’	745'	1420’

Exceeds the BioInitiative Recommendation of 0.1 uW/cm2 at this distance (in feet)

ANDERSON DEPOSITION EXHIBIT 5

EXPERT REPORT OF William Bathgate

McKnight v PECO, C-2017-2621057

1. Introduction and qualifications

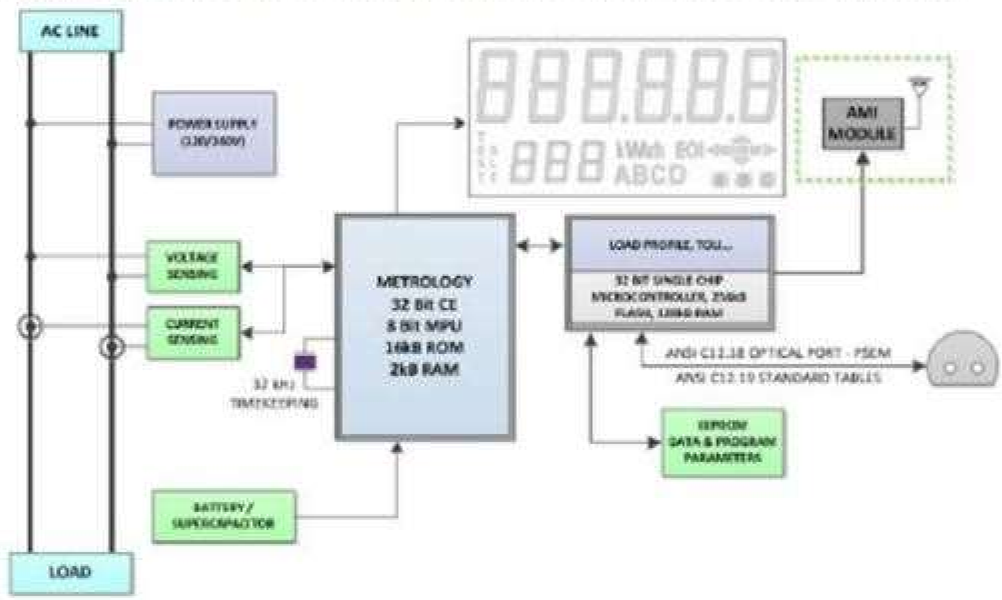
My name is William S. Bathgate, I am employed by TATA Consulting Services (TCS) as an assigned Program Manager for the FCA Automotive Group (Chrysler). My current assignment is for design of autonomous vehicles and the "Connected Vehicle" programs. This requires in-depth knowledge and experience in Radio Communication for WIFI, Cellular and electronic sensing systems for vehicle positioning accuracy. Prior to TATA I worked for Emerson Electric in high voltage / High Current power distribution system. I hold a Top Secret DoD Security Clearance and have been the lead on the design and manufacturing of the power and control systems for the THAD missile defense systems, seconded to Raytheon Corporation thru Emerson Electric. I have a degree in electrical engineering, with over 40 years of practical experience in commercial design and manufacturing of electrical power and computing systems such as the original IBM PC, S/370 Mainframe systems and intermediate platforms such as the AS/400, Unix and Linux systems. I may not have a PhD in electrical engineering, but no academic person has 40 years of practical experience in commercial endeavors in electrical and electronic systems.

In addition I have practical experience in High Voltage 115 KV to 138KV to Low Voltage <1000 Volts power conversion to enable power distribution in large industrial buildings such as the Sears Tower in Chicago, for example. I have been a leader of several design and manufacturing projects that use the same components as used in the AMI meters from several manufactures such as GE, ITRON, SENSUS, ACLARA and Landis+Gyr. I have disassembled each of these meters to understand the technology applied. My observations are that while there are differences in some of

the circuit components and the board layouts are different as used by different manufacturers the basic block diagram of all the meters are very close to one another. Here is an example of the block diagram.

Theory of Operation

This section contains the general circuit configuration for the I-210+c meter. The theory of operation of the I-210+c meter is described in the following sections.



These products are basically a small tablet computer with one or two radio transceivers and some come with a relay mechanism to disconnect power remotely. So there are no unique circuit components that are not also used in many industrial control and power switching systems in the market today. In addition I have lead the efforts to obtain product safety certifications, such as UL CSA, CE, PSE and other countries safety certification bodies for many of products I was responsible for. I am highly familiar with the test regimen for Switching Mode Power Supply compliance to FCC Class A and Class B Conducted emissions compliance, in addition to FCC RF Radiated radio emissions. For an explanation of what is a Class A or Class B device see Exhibit mck.wb.ep03.FCCoet62rev.pdf. My resume is attached to this report as Exhibit mck.wb.cv.pdf.

2. My Testing and discovery of the PECO AMI Meter

In my preparation for this case I obtained a GE I-210+C AMI Meter and an Aclara I-210+ meter. Aclara purchased the GE line of AMI meters in November of 2015. The two meters internally are the same despite the model number differences. The I-210+C is the same as the I-210+ meter except the C designation indicates it is a "Demand" regulated meter via the internal software of the computer. The C type meter can have a prepaid billing functions and Time of Use features enabled via a software change. Otherwise the two I-210+ and the I-210+C meter are electrically identical.

I setup a test rig see Exhibit mck.wb.ev01a.Smart Meter Test Setup 1.jpeg and mck.wb.ev01b.Smart Meter Test Setup 1.jpeg to test each of these meters in a controlled environment. I have a second home under a complete teardown state. There are no electrical appliances or other electric circuits active, not even a light bulb. There is no heat of any kind. The power company circuit is fed by an Analog meter. There are no electronic circuits in the Analog meter so there are no supplemental electrical effects that can disrupt the electrical measurements made. Measurements were made with a Laptop PC (An HP Elite book 6930p) and an Oscilloscope (a 100 MHz bandwidth two channel OWON SDS7102V with a sample rate of 1 Giga-samples per second) both were running on internal batteries so there were no added mains power used to power this equipment that could corrupt the meter readings. This OWON oscilloscope in use for these measurement is a current product and on the market for the last several years and is verified for accuracy supported by a current calibration certificate by the National Institute of Standards Testing (NIST). The other common measurement devices on the market today such as the Stetzerwizer Micro surge meter is limited in its ability to provide an actual voltage result, and is expressed in non-standard GS (Graham-Stetzer) units not volts, is limited in that it can only measure frequency signals up to 100 KHz, has a very slow sample

rate for measurements (as evidenced by the constant change with wide swings in indicated measurements) and is not calibrated with an actual certified test certificate from the NIST. Therefore it cannot be used as a precision instrument to make certified measurements testimony.

At the house that was used for this test the main power company power comes in to an isolated power transformer on a telephone pole with no other customers sharing the same transformer, into a meter housing with an Analog Meter then into a beaker panel and a 240 volts power connection plug, to the test rig, then to the Aclara I-210+ and/or the GE I-210+C meter. The 120 volts outlet of the A and B side alternately were connected to a special made 4 stage high pass filter that allowed channel 2 (in Yellow) to measure the voltage transients and frequencies beyond the dominant 60 Hz fundamental main power in Channel 1 (in Red). A high pass filter rejects (cuts off) the 60 Hz main power frequency and all frequencies below 60 Hz, but allows those above 60 Hz to pass on to the measurement oscilloscope. You have to have this high pass filter to conduct these types of measurements and is a common practice in electronic circuit design testing.

3. Test Results for Conducted Emissions of the PECO AMI Meter

In the chart file name Exhibit mck.ev02.Aclara I-210+ = no devices powered 3-25-2018 at 200mv scale for transients.jpeg and Exhibit mck.ev03.GE I-210+C = no devices powered 3-25-2018 at 200mv scale for transients.JPEG you see the 60 Hz mains power in red color (Channel 1) and the transients in yellow color (Channel 2). The red scale is 50 Volts per division for the mains power, and a division is a large square block on the chart, so while many people think the power outlets in their home are 120 volts, it is not the actual peak voltage. It is actually about 167 peak volts not 120. The common reference is to a 120 Volts RMS (Root Mean Square). The red waveform is called a sine wave and is a smooth in curvature and format. You can count the major division squares to see the peak of 167 volts above and below the centerline for a total peak to peak of about 334 volts. This is a normal condition.

In the yellow trace you will notice an erratic waveform that is at a 200 Millivolts scale per major division for an approximate peak to peak voltage of about 300 Millivolts. This voltage is called the conducted emissions and is created within the internal electronics of the meter in a circuit called a switched mode power supply (SMPS). This circuit converts the incoming 240 volts AC into the meter from the mains power transformer into much lower DC voltages that the electronics require to function. All electronic devices require DC volts to operate the electronic circuit chips in such devices. An AMI meter is both an AC and a DC device. As part of that conversion process there is a very fast switching circuit called a MOSFET transistor or similar electronic devices that can switch at very high frequencies anywhere from 16 KHz to 150 KHz depending on the design requirements. So the MOSFET or other circuit switching at 16 KHz or higher, unknown to many has numerous 1 thru 50 harmonic octaves of that 16 KHz, to 32 KHz, 64 KHz, 128 KHz and so forth. It can also go the other direction from 16 KHz, such as 8 KHz, 900 Hz and so forth. It is much like a tuning fork,

where there are octaves above and below the first fundamental frequency that go on and on. Just like a piano tuner uses to tune all the keys of a piano. In the Analog meter there are no electronic components that create these kind of transients see Exhibit mck.wb.ev08.Baseline – Analog Meter Baseline 200mv scale – no devices powered 3-25-2018.jpeg. During the testing conducted there were no electrical circuits present other than the electric meter and a power disconnect. This Analog meter was in place between the Mains power feed from the utility and the test setup. As you can see from this Exhibit mck.wb.ev08.Baseline – Analog Meter Baseline 200mv scale – no devices powered 3-25-2018.jpeg there are no perceptible transients present.

4. Other harmonics

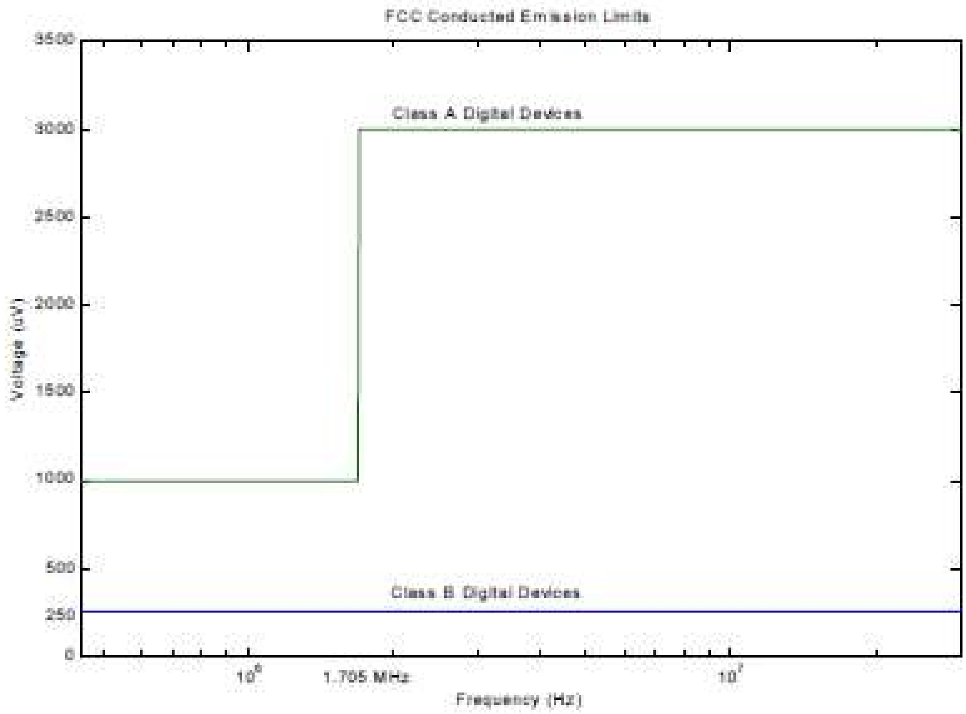
In the test conducted you will notice two other graphs with a Fast Fourier Transformation (FFT) representation. An FFT is an algorithm that samples a signal over a period of time and divides it into its frequency components. So, it is not necessary to overly analyze the FFT graph, but you can see the numerous frequencies present on the powerline and if I continued the graph it would go on thru at least 10 MHz or more. These are represented as Exhibit mck.wb.ev04.GE I-210+C = no devices powered 3-25-2018 at 200mv scale for transients FFT of Ch 2.JPG and as Exhibit mck.wb.ev05.Aclara I-210+ = no devices powered 3-25-2018 at 200mv scale for transients FFT of Ch 2.JPG. The pictures of the meters tested are in Exhibit mck.wb.ev06.aclara-meter.jpeg and Exhibit mck.wb.ev07.ge-I210+c.jpg.

5. Transients and the FCC Class B

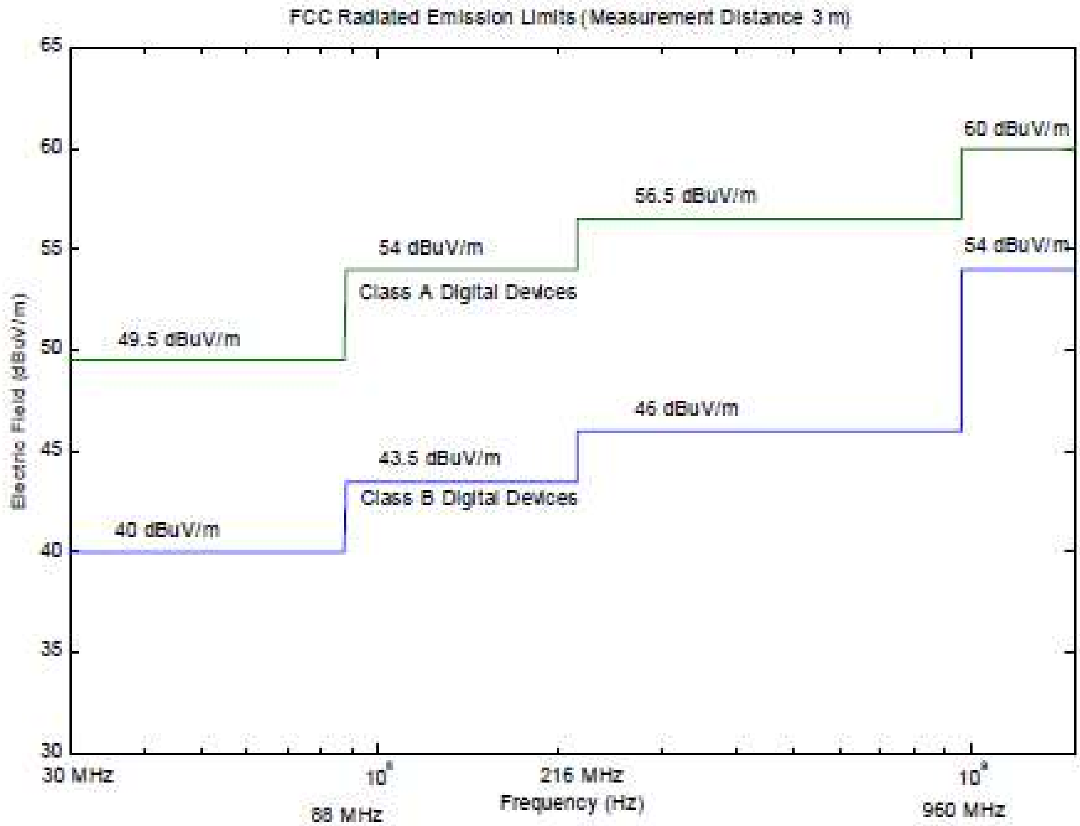
In the test conducted an observation made is the based on the comparison of the results to the FCC Class B specification which is for electronic based devices which the AMI certainly is, because it is not just a meter it is also a full-fledged computer too. So the FCC Class B

Specifications does apply. With the conducted emissions (not the RF emissions from the radio) there is a limit of 250 Microvolts (µV) (0.000250 V) across all frequencies, so with a measurement of about 300 Millivolts (mV) (0.300 V) the voltage transients exceed the specification by a multiple of 1200 times the maximum value and exceeds the FCC Class Specification as expressed in volts. These volts are injected onto the power lines of the home and could have been prevented by proper design of the AMI meter. This is not insignificant compared to other devices in the home. Other appliances, light bulbs etc. are not on 24/7 so a consumer can limit their exposure, unlike the AMI meter. In addition all other appliances and devices are compliant to the FCC Conducted Emissions specification, because they have the added circuit filtering to block the transients from being introduced back onto the mains power. There is also a frequency specification in the FCC Class B specification, but regardless of frequency spectrum limit, volts cannot exceed 250 Microvolts (250µV) at any frequency. Included here are two exhibits that summarize the FCC Conducted emissions. These exhibits came from Michigan State University as part of their Electrical Engineering curriculum and reference the appropriate FCC Specifications, but in an easier to read and understandable format. The first is called FCC Emissions module 8 regulations Exhibit mck.wb.ep01.FCC Module 8.pdf the second is FCC Emissions module 11 conducted Emissions Exhibit mck.wb.ep02.FCC Module 11.pdf.

In these two exhibits I will discuss two specific items, one the graph of Conducted Emissions for Class A and B devices and the second which discusses Radiated Emissions. We want to focus on the conducted emissions which are specified in volts across all frequencies.

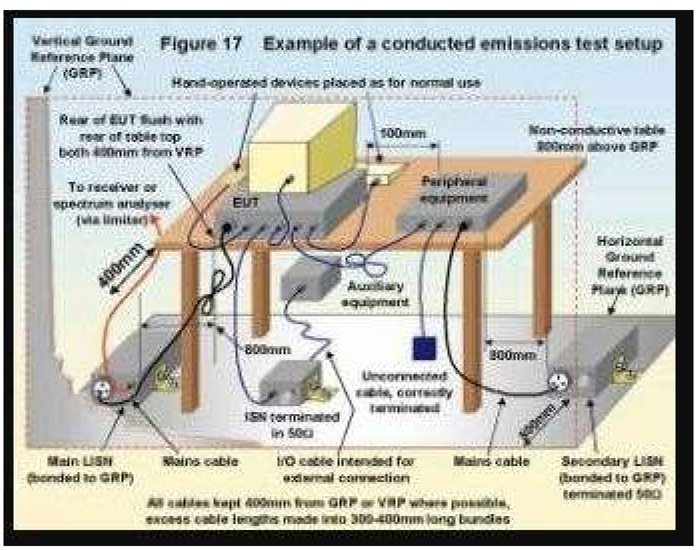


There is also radiated emissions in the form of RF emissions, as shown in the following chart, which is expressed in dbμv/m. But these radiated emissions are not easy to conduct in a field test such as we were able to perform. The Conducted emissions are relatively easy to test, and based on the results both meters we tested were not in compliance in terms of meeting 250 μV transients across all frequencies.

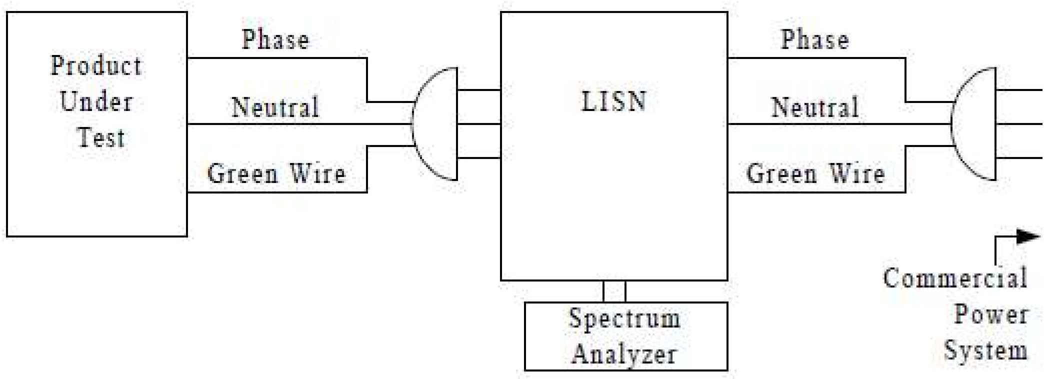


6. FCC Class B Test Regimen

In the FCC Class B test regimen for compliance there is a special set up required to conduct the frequency tests. The test setup looks like the following.

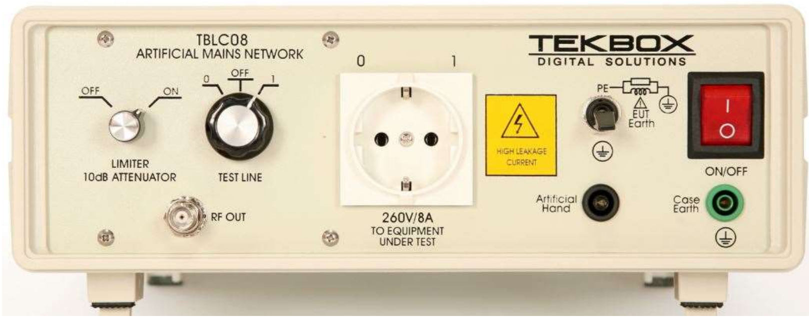


In addition the Product/Device under Test (DUT) requires a ground connection to conduct a valid frequency test as shown in the following diagram and in FCC Emissions module 11 conducted Emissions Exhibit mck.wb.ep02.FCC Module 11.pdf



The Line Impedance Stabilization Network (LISN) is a special device that provides "Unpolluted" power to the DUT. You will note that to conduct this test you must have a connection to ground and neutral for the DUT, there is no such connection in the AMI meter, therefore even if the meter manufactures conduct a test no valid test for conducted emissions could be properly performed or the test conducted did not reflect the in situ of normal meter operation which should include a connection to ground or even neutral. Given the test regimen required and the lack of a ground connection the electronics in the PECO AMI meter would never pass the FCC Class B specification and the manufactures product specification represented in the FCC ID does not express the meter passed the FCC Class B Conducted Emissions specification for either volts or frequencies. It does pass for radiated emissions for the radio transmitter's portion of the product. But this means the PECO AMI meter only passed half the required specifications. There is no "Carve Out" for the FCC Conducted Emissions compliance in any device.

Here is an example of an LISN, this is for testing for a European mains connection but the same type of configuration can be used in North America.



In summary the FCC has concluded that the law makes it illegal to market digital devices that have not had their conducted and radiated emissions measured and verified to be within the limits set for by the FCC regulations. This means that digital devices that have not been measured to pass the requirements cannot be sold, marketed, shipped, or even be offered for sale. Although the penalties for violating these regulations include fines and or jail time, companies are more concerned with the negative publicity that would ensue once it became known that they had marketed a product that fails to meet all FCC regulations. Furthermore, if the product in question were already made available to the public, the company would be forced to recall the product. Thus it is important that every unit that a company produces is fully FCC compliant, including conducted emissions. Although the FCC does not test each and every module, they do perform random tests on products and if a single unit fails to comply, the entire product line can be recalled. Since PECO has decided on the use of the Aclara I-210+ product line and other AMI meters as their standard, these units should be recalled for non-compliance for exceeding conducted emissions regulations, PECO staff have neglected to fully consider all the safe meter options. There is a safe digital meter alternative with the ITRON C1S meter that has been widely deployed in North America and in my testing of that model unit there is no SMPS, and it instead uses a capacitive based power supply that does not exceed the 250µV limits. There is also no radio transceivers in this ITRON C1S unit. PECO should investigate this type of capacitive power supply design to be incorporated in the meters they use or switch suppliers. Alternatively PECO

could make accommodations for customers that request a safer meter or be at risk for a class action by all PECO customers and action by the FCC for violation of specifications. Since Federal Law preempts State Law, PECO is in violation of Federal Law forcing customers to accept a non-compliant device onto the side of their homes.

PECO may make a stance that so many million meters have been deployed without issues, but how do they know this to be true? If PECO were to survey their entire customer base they will likely find most customers have a different view on the matter. So, when PECO expresses that they have no customer complaints about the AMI meters deployed, without a comprehensive customer survey of every customer this statement is misleading at best. To my knowledge no such survey has ever been conducted with regards to the new AMI meters deployed.

Williams S Bathgate

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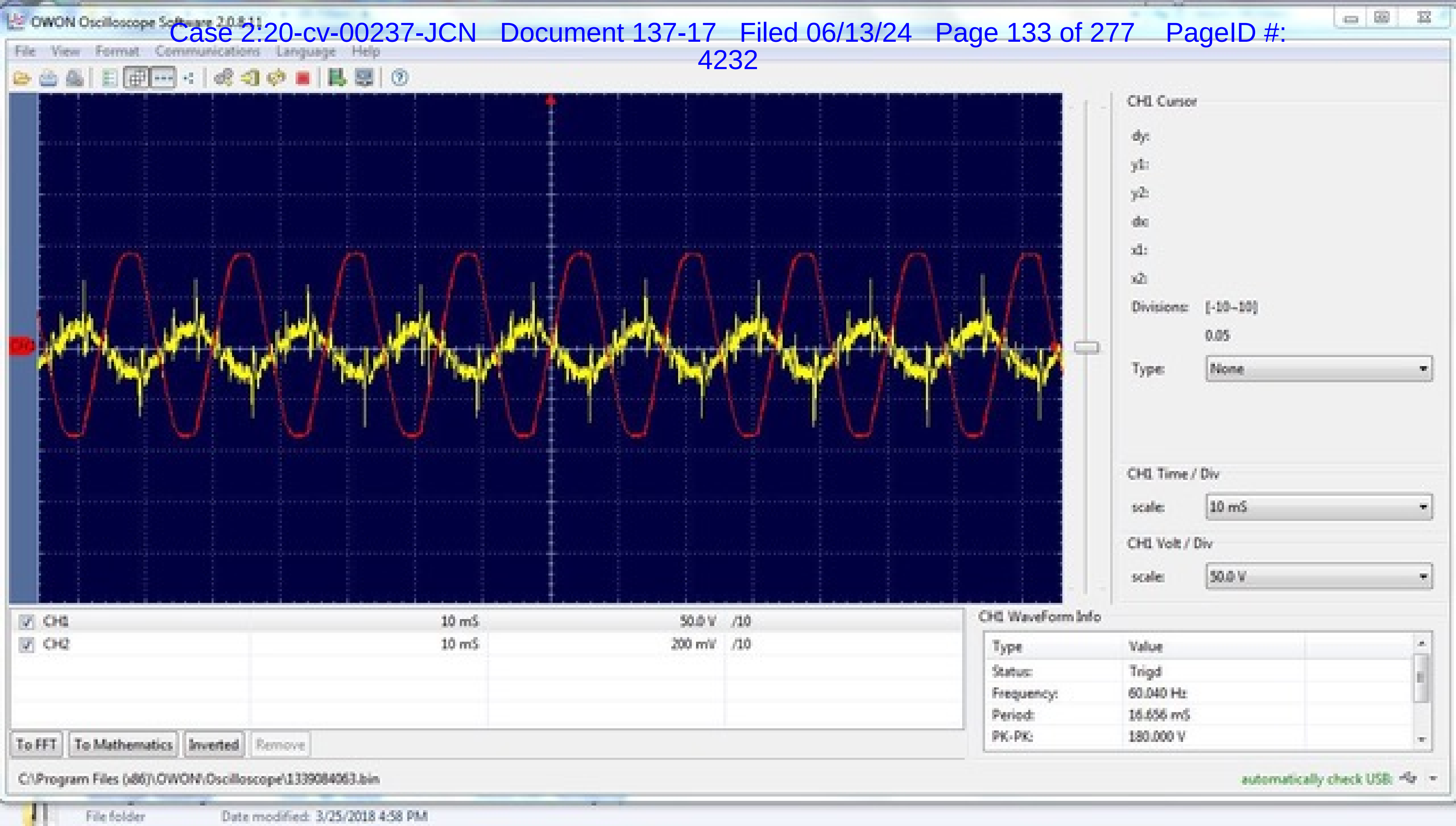
Pinckney, MI 48169

3-26-2018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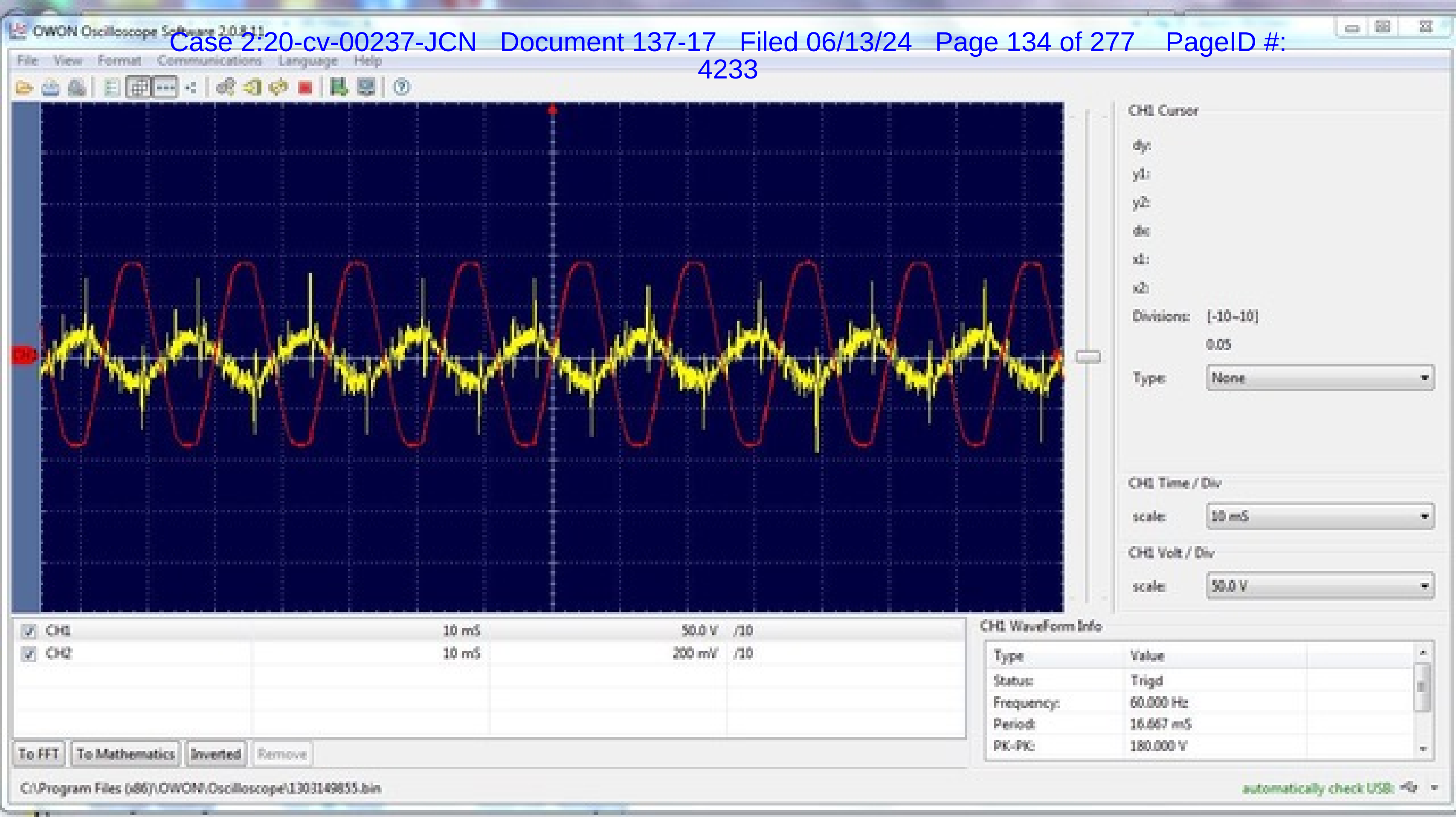
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CH1 Time / Div
scale: 10 mS
CH1 Volt / Div
scale: 50.0 V
CH1 10 mS 50.0 V /10
CH2 10 mS 200 mV /10
CH1 WaveForm Info
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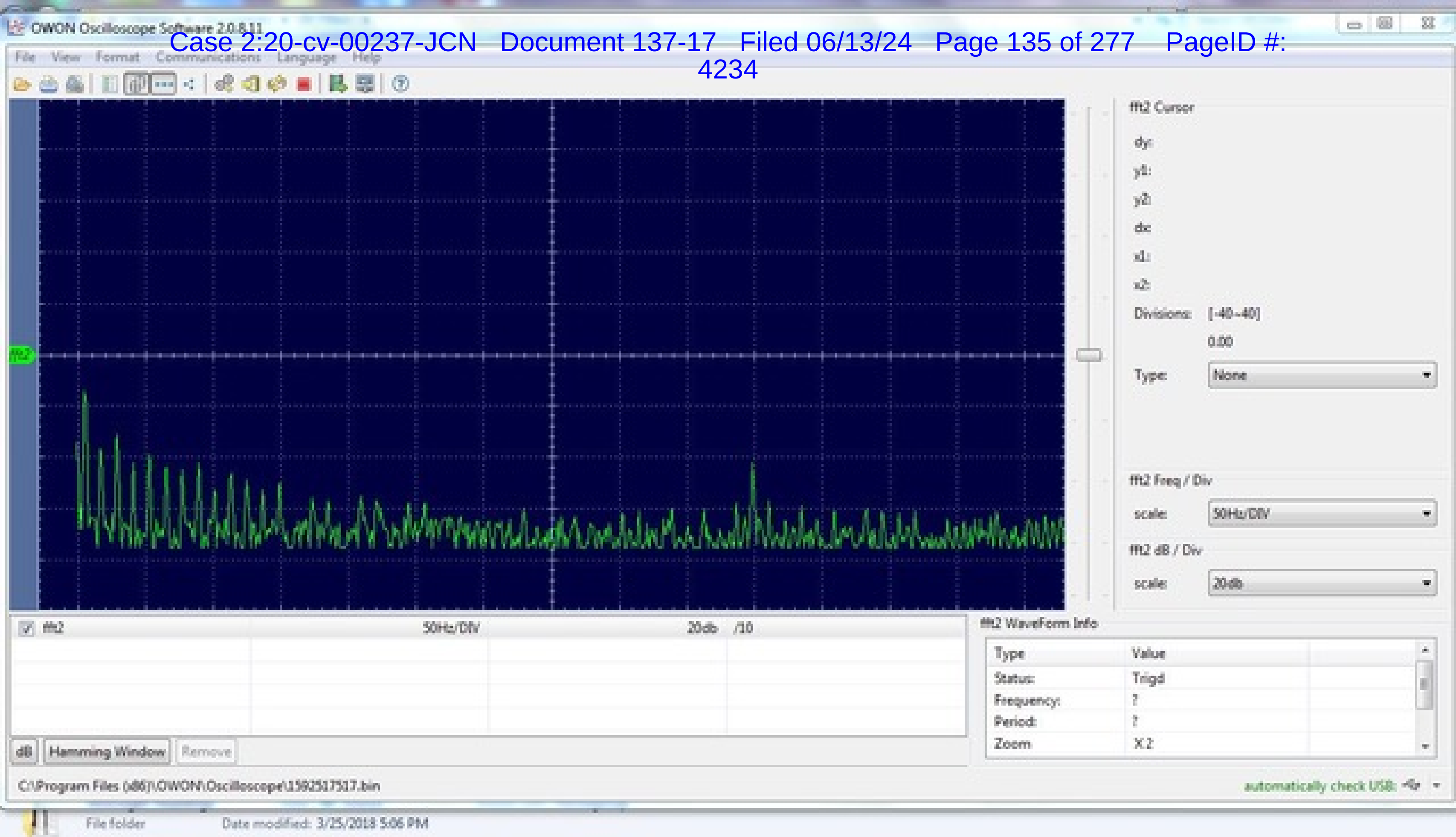
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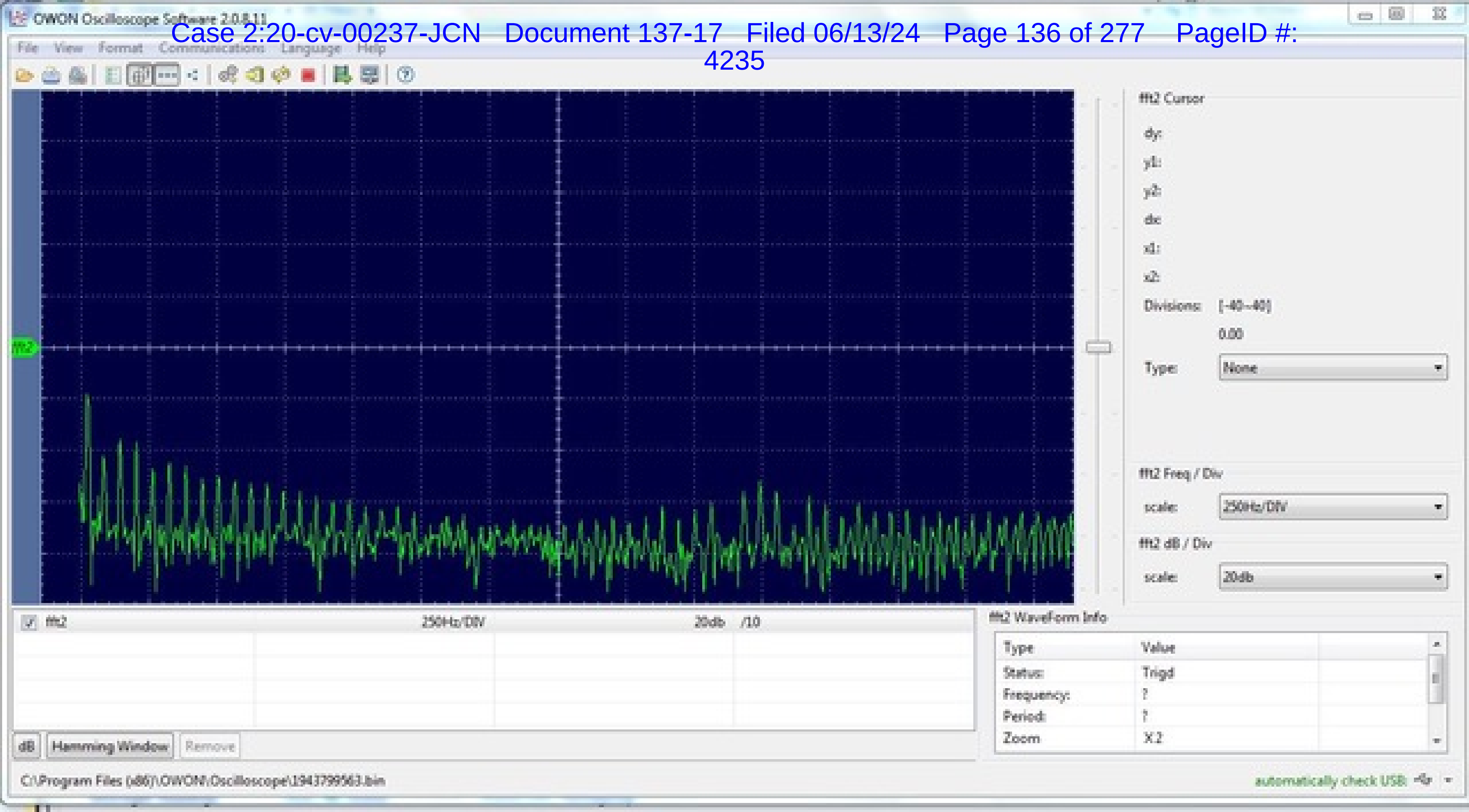
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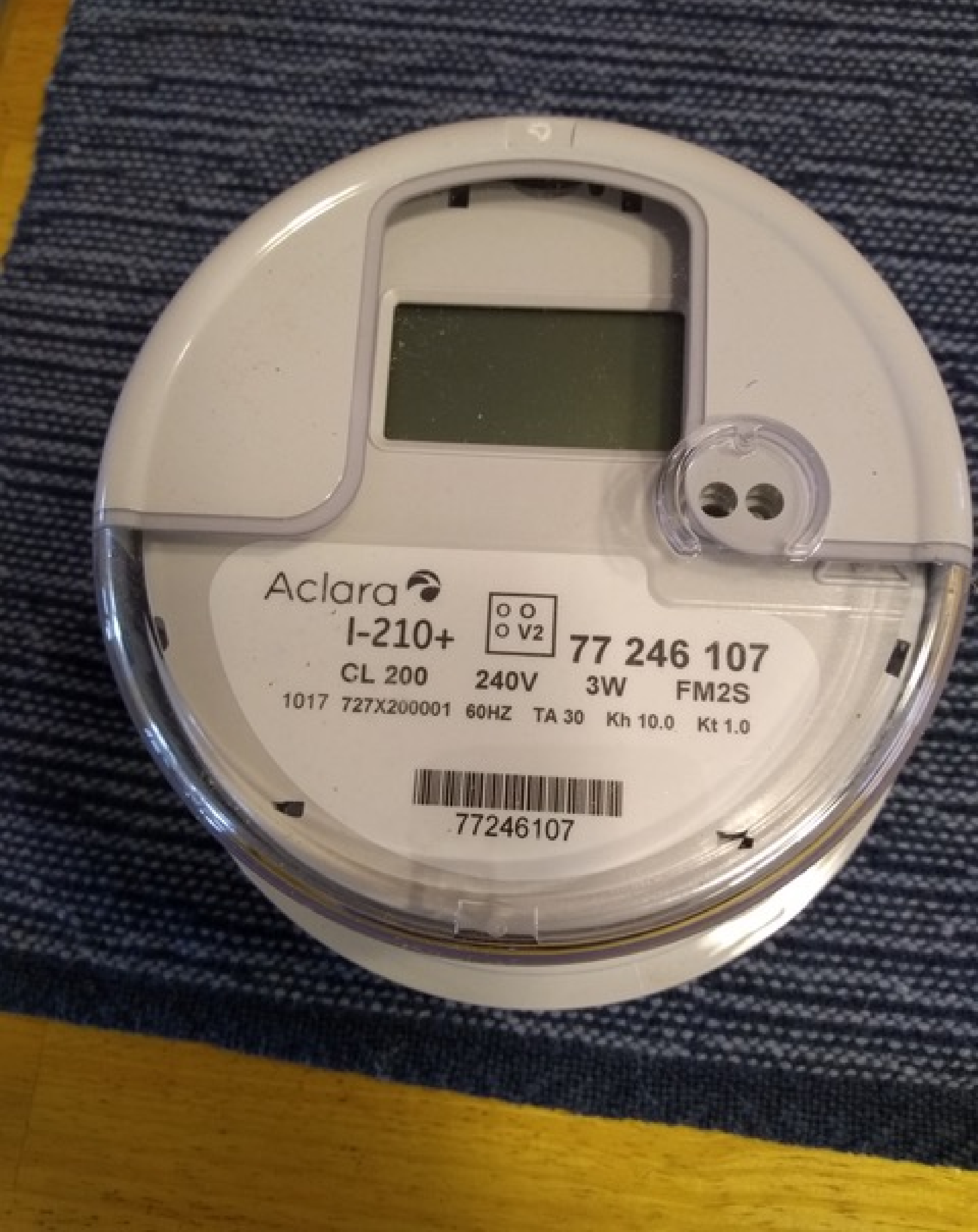
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V2
77 246 107
CL 200 240V 3W FM2S
1017 727X200001 60HZ TA 30 Kh 10.0 Kt 1.0
77246107


I-210+C
T2
R2
V2
K2
A2
N2
E2
Q2
60 243 830
240V
3W
FM2S
1602
USA
0214
CL 200
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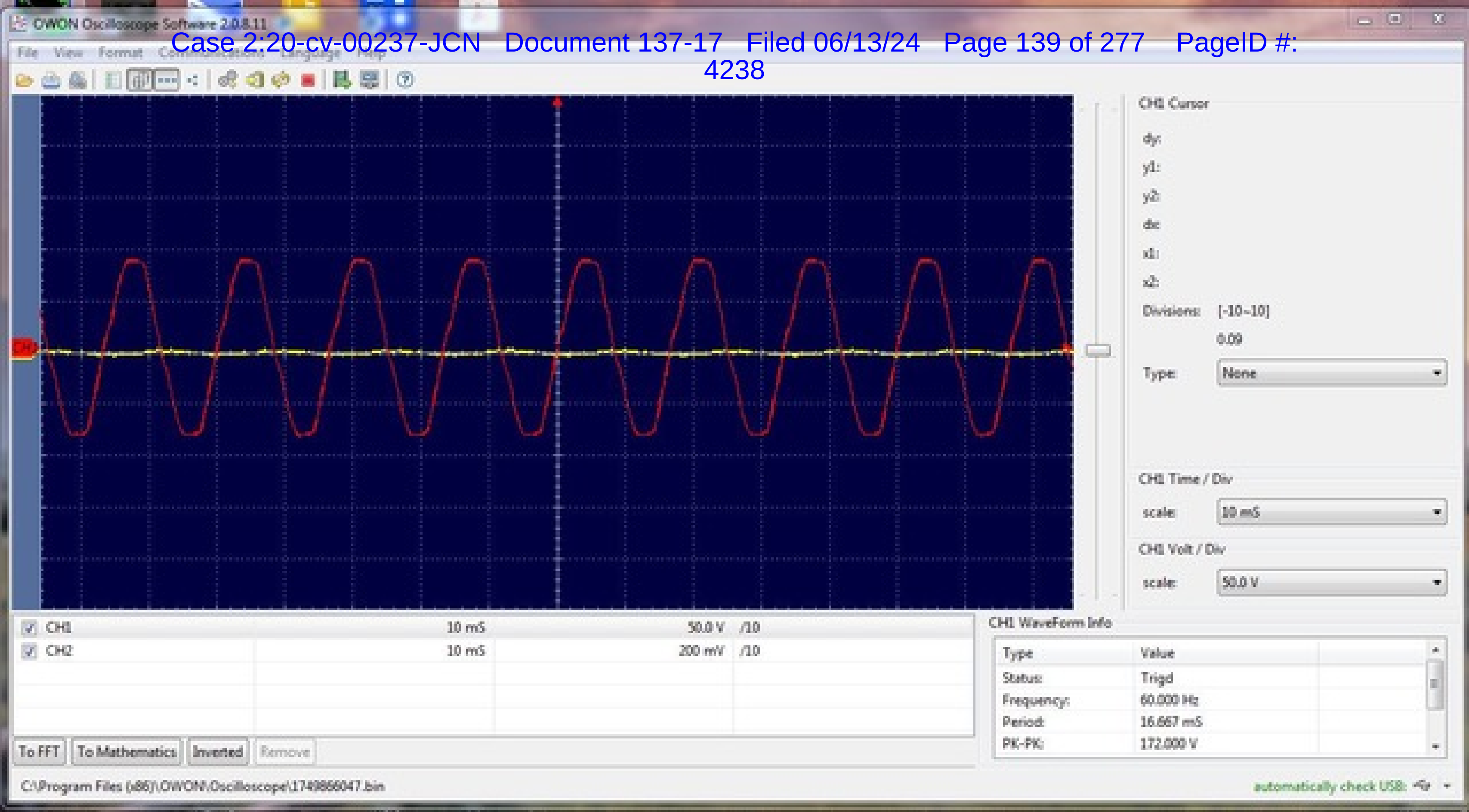
Kh 10.0
Kt 1.0
60243830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y1:
y2:
dx:
x1:
x2:
Divisions: [-10~10]
0.09
Type: None
CH1 Time / Div
scale: 10 mS
CH1 Volt / Div
scale: 50.0 V
CH1 10 mS 50.0 V /10
CH2 10 mS 200 mV /10
CH1 WaveForm Info
Type Value
Status: Trigd
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PK-PK: 172.000 V
To FFT To Mathematics Inverted Remove
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automatically check USB:

Office of Engineering and Technology
Federal Communications Commission

UNDERSTANDING THE FCC REGULATIONS

FOR LOW-POWER, NON-LICENSED TRANSMITTERS

OET BULLETIN NO. 63

October 1993
(Supersedes September 1984 Issue)
(Edited and Reprinted February 1996)

Forward

This bulletin provides a basic understanding of the FCC regulations for low-power, unlicensed transmitters, followed by some answers to commonly-asked questions. To assist readers in locating specific rules, the rule references are displayed in a column to the right of the text.

We welcome comments on improvements that can be made to this bulletin. Please address such comments to:

Federal Communications Commission
Office of Engineering and Technology
Customer Service Branch, MS 1300F2
7435 Oakland Mills Road
Columbia, MD 21046
Fax: (301) 344-2050
E-Mail: labinfo@fcc.gov

Note: Editorial changes have been made in this bulletin to reflect changes in the cordless telephone frequencies, the names, addresses and telephone numbers of information sources and FCC offices. This bulletin does not contain information concerning personal communication services (PCS) transmitters operating under Part 15, Subpart D of the rules. The FCC rules and regulations governing PCS transmitters may be found in 47 CFR, Parts 0 to 19. This bulletin also does not cover recent changes in the rules to accomodate devices operating above 40 GHz (millimeter waves). These changes will be discussed in later editions of this bulletin.

The fees listed in this bulletin reflect those in effect at the time of printing, but are subject to change. Current fee information can be obtained from The FCC's Public Access Link (PAL) and the Office of Engineering and Technology (OET) Fee Filing Guide. See "***FCC's computer bulletin board***" and ***"Obtaining forms and fee filing guides"*** under **Additional Information** on pages 31 and 32 of this bulletin.

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FEDERAL COMMUNICATIONS COMMISSION
Office of Engineering and Technology
Washington, DC 20554

UNDERSTANDING THE FCC REGULATIONS FOR LOW-POWER, NON-LICENSED TRANSMITTERS

OET Bulletin 63
October, 1993
Edited and reprinted Feb. 1996

Introduction

Low-power, non-licensed transmitters are used virtually everywhere. Cordless phones, baby monitors, garage door openers, wireless home security systems, keyless automobile entry systems and hundreds of other types of common electronic equipment rely on such transmitters to function. At any time of day, most people are within a few meters of consumer products that use low-power, non-licensed transmitters.

Non-licensed transmitters operate on a variety of frequencies. They must share these frequencies with licensed transmitters and are prohibited from causing interference to licensed transmitters.

The Federal Communications Commission (FCC) has rules to limit the potential for harmful interference to licensed transmitters by low-power, non-licensed transmitters. In its regulations, the FCC takes into account that different types of products that incorporate low-power transmitters have different potentials for causing harmful interference. As a result, the FCC's regulations are most restrictive on products that are most likely to cause harmful interference, and less restrictive on those that are least likely to cause interference.

This bulletin is intended to provide a general understanding of the FCC's regulations and policies applying to products using low-power transmitters. It reflects the current text and interpretations of the FCC's regulations. More detailed information is contained in the regulations themselves, which can be found in Part 15 of Title 47 of the Code of Federal Regulations. This bulletin does not replace or supersede those regulations.

Manufacturers and parties selling low-power, non-licensed transmitters, or products containing low-power, non-licensed transmitters, are strongly encouraged to review the FCC's regulations closely. Recognizing that new uses of low-power transmitters often generate questions that are not directly addressed in the regulations, we welcome inquiries or requests for specific interpretations. Occasionally, the FCC proposes changes to its regulations, generally to address industry concerns and/or as new uses of low-power transmission equipment appear. See the section titled **Additional Information** for information on obtaining the FCC regulations, requesting interpretations, and finding out about proposed rule changes.

Low-Power, Non-Licensed Transmitters

Throughout this bulletin the terms "low-power transmitter," "low-power, non-licensed transmitter," and "Part 15 transmitter" all refer to the same thing: a low-power, non-licensed transmitter that complies with the regulations in Part 15 of the FCC rules. Part 15 transmitters use very little power, most of them less than a milliwatt. They are "non-licensed" because their operators are not required to obtain a license from the FCC to use them. Section 15.1

Although an operator does not have to obtain a license to use a Part 15 transmitter, the transmitter itself is required to have an FCC authorization before it can be legally marketed in the United States. This authorization requirement helps ensure that Part 15 transmitters comply with the Commission's technical standards and, thus, are capable of being operated with little potential for causing interference to authorized radio communications. Section 15.201 Section 2.803

If a Part 15 transmitter does cause interference to authorized radio communications, even if the transmitter complies with all of the technical standards and equipment authorization requirements in the FCC rules, then its operator will be required to cease operation, at least until the interference problem is corrected. Section 15.5

Part 15 transmitters receive no regulatory protection from interference.

Antenna Requirement

Changing the antenna on a transmitter can significantly increase, or decrease, the strength of the signal that is ultimately transmitted. Except for cable locating equipment, the standards in Part 15 are not based solely on output power but also take into account the antenna characteristics. Thus, a low power transmitter that complies with the technical standards in Part 15 with a particular antenna attached can exceed the Part 15 standards if a different antenna is attached. Should this happen it could pose a serious interference problem to authorized radio communications such as emergency, broadcast and air-traffic control communications.

In order to prevent such interference problems, each Part 15 transmitter must be designed to ensure that no type of antenna can be used with it other than the one used to demonstrate compliance with the technical standards. This means that Part 15 transmitters must have permanently attached antennas, or detachable antennas with unique connectors. A "unique connector" is one that is not of a standard type found in electronic supply stores. Section 15.203

It is recognized that suppliers of Part 15 transmitters often want their customers to be able to replace an antenna if it should break. With this in mind, Part 15 allows transmitters to be designed so that the user can replace a broken antenna. When this is done, the replacement antenna must be electrically identical to the antenna that was used to obtain FCC authorization for the transmitter. The replacement antenna also must include the unique connector described above to ensure it is used with the proper transmitter.

Home-Built Transmitters that are Not for Sale

Hobbyists, inventors and other parties that design and build Part 15 transmitters with no intention of ever marketing them may construct and operate up to five such transmitters for their own personal use without having to obtain FCC equipment authorization. If possible, these transmitters should be tested for compliance with the Commission's rules. If such testing is not practicable, their designers and builders are required to employ good engineering practices in order to ensure compliance with the Part 15 standards. Section 15.23

Home-built transmitters, like all Part 15 transmitters, are not allowed to cause interference to licensed radio communications and must accept any interference that they receive. If a home-built Part 15 transmitter does cause interference to licensed radio communications, the Commission will require its operator to cease operation until the interference problem is corrected. Furthermore, if the Commission determines that the operator of such a transmitter has not attempted to ensure compliance with the Part 15 technical standards by employing good engineering practices then that operator may be fined up to $10,000 for each violation and $75,000 for a repeat or continuing violation. Section 15.5 47 U.S.C. 503

Operating a prototype of a product that is ultimately intended for market is not considered "personal use." Thus, a party that designs and builds a transmitter with plans to mass produce and market a future version of it must obtain an experimental license from the FCC in order to operate the transmitter for any purpose other than testing for compliance with the Part 15 technical standards. Information on experimental licenses may be obtained from the contact point listed in the **Additional Information** section of this bulletin. FCC authorization is not required in order to test a transmitter for compliance with the Part 15 technical standards. Section 15.7 47 CFR Part 5

Equipment Authorization

A Part 15 transmitter must be tested and authorized before it may be marketed. There are two ways to obtain authorization: certification and verification. Section 15.201 Section 2.803 47 U.S.C. 302(b)

Certification

The ***certification*** procedure requires that tests be performed to measure the levels of radio frequency energy that are radiated by the device into the open air or conducted by the device onto the power lines. A description of the measurement facilities of the laboratory where these tests are performed must be on file with the Commission's laboratory or must accompany the certification application. After these tests have been performed, a report must be produced showing the test procedure, the test results, and some additional information about the device including design drawings. The specific information that must be included in a certification report is detailed in Part 2 of the FCC Rules. Section 2.948 Section 2.1033 Section 2.938 Section 2.1033

Certified transmitters also are required to have two labels attached: an FCC ID label and a compliance label. The FCC ID label identifies the FCC equipment authorization file that is associated with the transmitter, and serves as an indication to consumers that

the transmitter has been authorized by the FCC. The compliance label indicates to consumers that the transmitter was authorized under Part 15 of the FCC rules and that it may not cause, nor is it protected from, harmful interference.

The FCC ID. The FCC ID must be permanently marked (etched, engraved, indelibly printed, etc.) either directly on the transmitter, or on a tag that is permanently affixed (riveted, welded, glued, etc.) to it. The FCC ID label must be readily visible to the purchaser at the time of purchase. Section 2.925

The FCC ID is a string of 4 to 17 characters. It may contain any combination of capital letters, numbers, or the dash/hyphen character. Characters 4 through 17 may be designated, as desired, by the applicant. The first three characters, however, are the "grantee code," a code assigned by the FCC to each particular applicant (grantee). Any application filed with the FCC must have an FCC ID that begins with an assigned grantee code. Section 2.925 Section 2.926

The Grantee Code. To obtain a code, new applicants must send in a letter stating the applicant's name and address and requesting a grantee code. This letter must be accompanied by a completed "Fee Advice Form" (FCC Form 159), and a $45 processing fee. See *Obtaining...filing packets* on page 31. Section 1.1103

The Compliance Label. The applicant for a grant of certification is responsible for having the compliance label produced and for having it affixed to each device that is marketed or imported. The wording for the compliance label is in Part 15, and may be included on the same label as the FCC ID, if desired. Section 15.19

The compliance label and FCC ID label may not be attached to any devices until a grant of certification has been obtained for the devices. Section 2.926

Once the report demonstrating compliance with the technical standards has been completed, and the compliance label and FCC ID label have been designed, the party wishing to get the transmitter certified (it can be anyone) must file a copy of the report, an "Application for Equipment Authorization" (FCC Form 731) and an $845 application fee, with the FCC. See *Obtaining...filing packets* on page 31. Section 2.911 Section 2.1033 Section 1.1103

After the application is submitted, the FCC's lab will review the report and may or may not request a sample of the transmitter to test. If the application is complete and accurate, and any tests performed by the FCC's lab confirm that the transmitter is compliant, the FCC will then issue a grant of certification for the transmitter. Marketing of the transmitter may begin after the applicant has received a copy of this grant. Section 2.943 Section 2.803

Typically, 90% of the applications for certification that the FCC receives are processed within 30 calendar days. This time frame may increase due to incomplete applications and pre-grant sampling, if determined to be necessary. Section 2.943

Verification

The ***verification*** procedure requires that tests be performed on the transmitter to be authorized using a laboratory that has calibrated its test site or, if the transmitter is incapable of being tested at a laboratory, at the installation site. These tests measure the levels of radio frequency energy that are radiated by the transmitter into the open air or conducted by the transmitter onto the power lines. After these tests are performed, a report must be produced showing the test procedure, the test results, and some additional information about the transmitter including design drawings. The specific information that must be included in a verification report is detailed in Part 2 of the FCC Rules. Sections 2.951 through 2.957

Once the report is completed, the manufacturer (or importer for an imported device) is required to keep a copy of it on file as evidence that the transmitter meets the technical standards in Part 15. The manufacturer (importer) must be able to produce this report on short notice should the FCC ever request it. Section 2.955 Section 2.956

The Compliance Label. The manufacturer (or importer) is responsible for having the compliance label produced, and for having it affixed to each transmitter that is marketed or imported. The wording for the compliance label is included in Part 15. Verified transmitters must be uniquely identified with a brand name and/or model number that cannot be confused with other, electrically different transmitters on the market. However, they may not be labelled with an FCC ID or in a manner that could be confused with an FCC ID. Section 15.19 Section 2.954

Once the report showing compliance is in the manufacturer's (or importer's) files and the compliance label has been attached to the transmitter, marketing of the transmitter may begin. ***There is no filing with the FCC required for verified equipment.*** Section 2.805

Any equipment that connects to the public switched telephone network, such as a cordless telephone, is also subject to regulations in Part 68 of the FCC Rules and must be registered by the FCC prior to marketing. The rules in Part 68 are designed to protect against harm to the telephone network. Section 68.102

Authorization Procedures for Part 15 Transmitters

Low Power Transmitter	Authorization Procedure
AM-band transmission systems on the campuses of educational institutions	Verification
Cable locating equipment at or below 490 kHz	Verification
Carrier current systems	Verification
Devices, such as a perimeter protection systems, that must be measured at the installation site	Verification of first three installations with resulting data immediately used to obtain certification
Leaky coaxial cable systems	If designed for operation exclusively in the AM broadcast band: verification; otherwise: certification
Tunnel radio systems	Verification
All other Part 15 transmitters	Certification

The Verification Procedure

TEST TRANSMITTER FOR RADIO FREQUENCY EMISSIONS (LAB FEES AND SPEED OF SERVICE VARY WIDELY - CONTACT SOME LABS IN YOUR AREA TO ESTIMATE SPEED AND COST OF SERVICE)

↓

ONCE TESTS INDICATE THAT TRANSMITTER COMPLIES WITH FCC STANDARDS, DESIGN COMPLIANCE LABEL AND AFFIX IT TO ALL DEVICES TO BE MARKETED

PRODUCE REPORT SHOWING TEST RESULTS

↓

MAINTAIN COPY OF TEST REPORT AND EQUIPMENT DESCRIPTION IN FILES OF MANUFACTURER (IMPORTER IF THE EQUIPMENT IS IMPORTED)

↓

TRANSMITTER IS NOW VERIFIED AND MARKETING MAY BEGIN (NO FILING WITH THE FCC IS REQUIRED FOR VERIFICATION)

The Certification Procedure

MAIL LETTER REQUESTING GRANTEE CODE, FCC FORM 159, AND $45 FILING FEE TO FCC'S MELLON BANK SERVICE CENTER <u>IN PITTSBURGH, PA ONLY IF</u> YOU'RE A NEW APPLICANT (7-10 DAY RESPONSE TIME)

TEST TRANSMITTER FOR RADIO FREQUENCY EMISSIONS (LAB FEES AND SPEED OF SERVICE VARY WIDELY - CONTACT SOME LABS IN YOUR AREA TO ESTIMATE SPEED AND COST OF SERVICE)

↓

ONCE TESTS INDICATE THAT TRANSMITTER COMPLIES WITH FCC TECHNICAL STANDARDS, ASSIGN FCC ID TO TRANSMITTER AND DESIGN COMPLIANCE LABEL

↓

FILE FCC FORM 731, $845 FILING FEE, EMISSIONS TEST REPORT, AND OTHER INFORMATION REQUIRED BY THE RULES WITH FCC'S MELLON BANK SERVICE CENTER IN PITTSBURGH, PA (≈30 DAY RESPONSE TIME)

↓

RECEIVE GRANT OF CERTIFICATION (OR DENIAL) IN MAIL FROM FCC

IF A GRANT IS RECEIVED, THE TRANSMITTER IS NOW CERTIFIED AND MARKETING MAY BEGIN

Certification:
Sections 2.1031 through 2.1045

Verification:
Sections 2.951 through 2.957

Technical Standards

Conducted emission limits

Part 15 transmitters that obtain power from the electrical power lines are subject to conducted emission standards that limit the amount of radio frequency energy they can conduct back onto these lines in the band 450 kHz - 30 MHz. This limit is 250 microvolts. Section 15.207

An exception to the conducted emission requirements is made for carrier current systems. These systems are not subject to any conducted emission limits unless they produce emissions (fundamental or harmonic) in the 535 kHz - 1,705 kHz band and are not intended to be received by standard AM broadcast receivers, in which case they are subject to a 1,000 microvolt limit.

Although carrier current systems are, for the most part, not subject to conducted emission limits, they are still subject to radiated emission limits.

Radiated emission limits

Section 15.209 contains general radiated emission (signal strength) limits that apply to all Part 15 transmitters using frequencies at 9 kHz and above. There are also a number of *restricted bands* in which low power, non-licensed transmitters are not allowed to operate because of potential interference to sensitive radio communications such as aircraft radionavigation, radio astronomy and search and rescue operations. If a particular transmitter can comply with the general radiated limits, and at the same time avoid operating in one of the restricted bands, then it can use any type of modulation (AM, FM, PCM, etc.) for any purpose. Section 15.209 Section 15.205

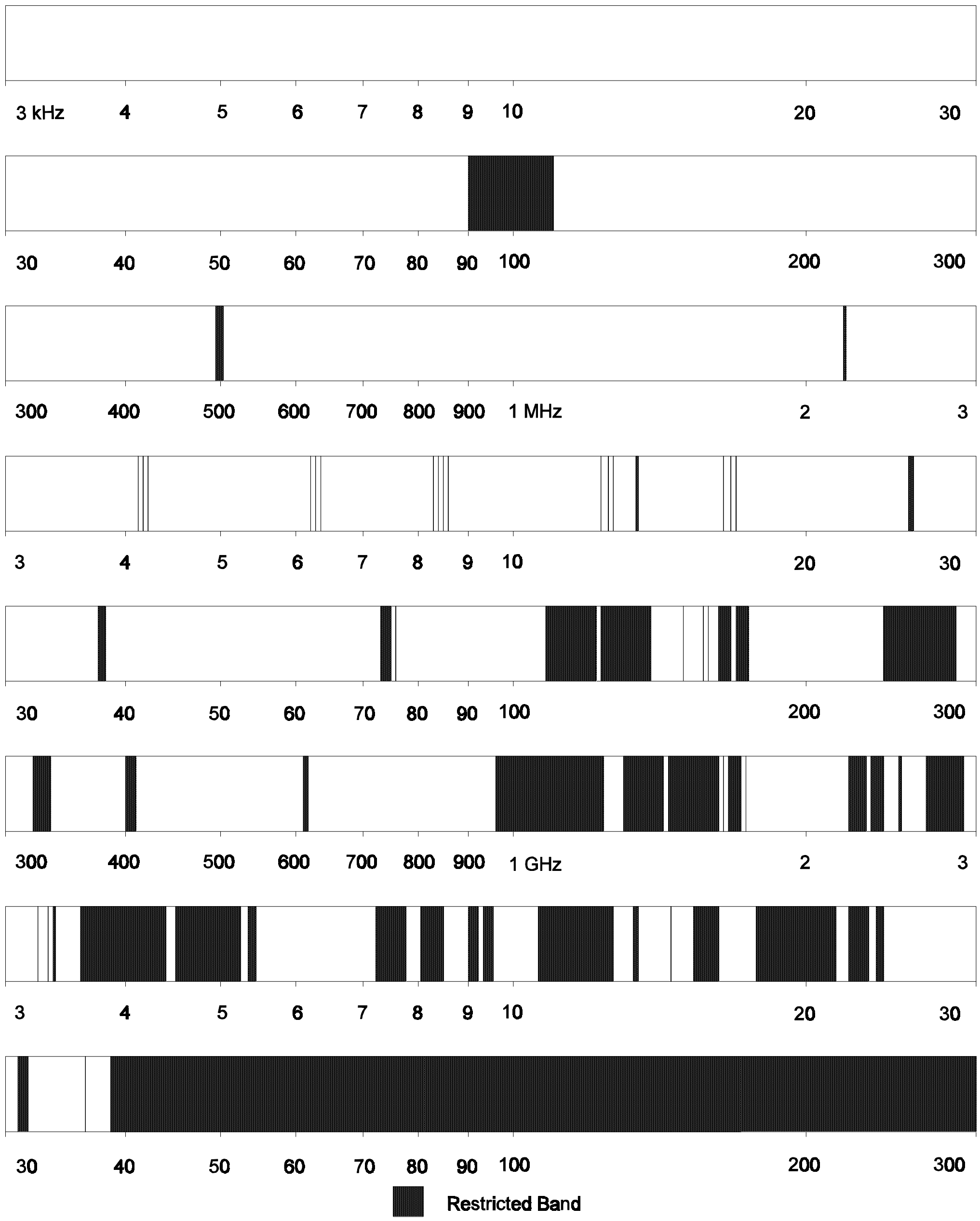
With the exception of intermittent and periodic transmissions, and biomedical telemetry devices, Part 15 transmitters are ***not*** permitted to operate in the TV broadcast bands.

Special provisions have been made in the Part 15 rules for certain types of transmitters that require a stronger signal strength on certain frequencies than the general radiated emission limits provide. For example, such provisions have been made for cordless telephones, auditory assistance devices and field disturbance sensors, among other things.

The following table illustrates where, in the radio frequency spectrum, the Part 15 restricted bands lie. The table after that illustrates what type of Part 15 operation is permitted for every frequency above 9 kHz, the emission limit for that type of operation, and the type of detector ("Det") used to measure emissions (average with a peak limit, "A," or quasi-peak, "Q"). When a transmitter power limit is specified instead of an emission limit, no emission detector is specified. Section 15.209 Section 15.205 Sections 15.215 through 15.251 Section 15.35

The Part 15 Restricted Bands - Spurious Emissions Only

Section 15.205



Part 15 low-power transmitter frequency table

Frequency Band	Type of Use	Emission Limit	Det	47 CFR
9-45 kHz	Cable locating equipment	10 Watts peak output power		15.213
	Any	2400/f(kHz) µV/m @ 300 m	A	15.209
45-90 kHz	Cable locating equipment	1 Watt peak output power		15.213
	Any	2400/f(kHz) µV/m @ 300 m	A	15.209
90-101.4 kHz	Cable locating equipment	1 Watt peak output power		15.213
101.4 kHz	Cable locating equipment	1 Watt peak output power		15.213
	Telephone company electronic marker detectors	23.7 µV/m @ 300 m	A	15.205
101.4-110 kHz	Cable locating equipment	1 Watt peak output power		15.213
110-160 kHz	Cable locating equipment	1 Watt peak output power		15.213
	Any	2400/f(kHz) µV/m @ 300 m	A	15.209
160-190 kHz	Cable locating equipment	1 Watt peak output power		15.213
	Any	1 Watt input to final RF stage		15.217
	Any	2400/f(kHz) µV/m @ 300 m	A	15.209
190-490 kHz	Cable locating equipment	1 Watt peak output power		15.213
	Any	2400/f(kHz) µV/m @ 300 m	A	15.209
490-495 kHz (before 2/1/99)	SPURIOUS EMISSIONS ONLY	24000/f(kHz) µV/m @ 30 m	Q	15.205
490-495 kHz (cont.) (on or after 2/1/99)	Any	24000/f(kHz) µV/m @ 30 m	Q	15.209
495-505 kHz	SPURIOUS EMISSIONS ONLY	24000/f(kHz) µV/m @ 30 m	Q	15.205
505-510 kHz (before 2/1/99)	SPURIOUS EMISSIONS ONLY	24000/f(kHz) µV/m @ 30 m	Q	15.205
(on or after 2/1/99)	Any	24000/f(kHz) µV/m @ 30 m	Q	15.209

510-525 kHz	Any	100 mW input to final RF stage		15.219
	Any	24000/f(kHz) μV/m @ 30 m	Q	15.209
525-1705 kHz	Any	100 mW input to final RF stage		15.219
	Transmitters on grounds of educational institutions	24000/f(kHz) μV/m @ 30 m outside of campus boundary	Q	15.221
	Carrier current & leaky coax systems	15 μV/m @ 47,715/f(kHz) m from cable	Q	15.221
	Any	24000/f(kHz) μV/m @ 30 m	Q	15.209
1.705-2.1735 MHz	Any, when 6 dB bandwidth ≥ 10% of center frequency	100 μV/m @ 30 m	A	15.223
	Any, when 6 dB bandwidth < 10% of center frequency	15 μV/m @ 30 m or bandwidth in (kHz) / f(MHz)	A	15.223
	Any	30 μV/m @ 30 m	Q	15.209
2.1735-2.1905 MHz	Swept frequency field disturbance sensors	30 μV/m @ 30 m	Q	15.205
2.1905-4.125 MHz	Any, when 6 dB bandwidth ≥ 10% of center frequency	100 μV/m @ 30 m	A	15.223
	Any, when 6 dB bandwidth < 10% of center frequency	15 μV/m @ 30 m or bandwidth in (kHz) / f(MHz)	A	15.223
	Any	30 μV/m @ 30 m	Q	15.209
4.125-4.128 MHz	Swept frequency field disturbance sensors	30 μV/m @ 30 m	Q	15.205
4.128-4.17725 MHz	Any, when 6 dB bandwidth ≥ 10% of center frequency	100 μV/m @ 30 m	A	15.223
	Any, when 6 dB bandwidth < 10% of center frequency	15 μV/m @ 30 m or bandwidth in (kHz) / f(MHz)	A	15.223
	Any	30 μV/m @ 30 m	Q	15.209
4.17725-4.17775 MHz	Swept frequency field disturbance sensors	30 μV/m @ 30 m	Q	15.205
4.17775-4.20725 MHz	Any, when 6 dB bandwidth ≥ 10% of center frequency	100 μV/m @ 30 m	A	15.223
	Any, when 6 dB bandwidth < 10% of center frequency	15 μV/m @ 30 m or bandwidth in (kHz) / f(MHz)	A	15.223

	Any	30 µV/m @ 30 m	Q	15.209
4.20725-4.20775 MHz	Swept frequency field disturbance sensors	30 µV/m @ 30 m	Q	15.205
4.20775-6.215 MHz	Any, when 6 dB bandwidth ≥ 10% of center frequency	100 µV/m @ 30 m	A	15.223
	Any, when 6 dB bandwidth < 10% of center frequency	15 µV/m @ 30 m or bandwidth in (kHz) / f(MHz)	A	15.223
	Any	30 µV/m @ 30 m	Q	15.209
6.215-6.218 MHz	Swept frequency field disturbance sensors	30 µV/m @ 30 m	Q	15.205
6.218-6.26775 MHz	Any, when 6 dB bandwidth ≥ 10% of center frequency	100 µV/m @ 30 m	A	15.223
	Any, when 6 dB bandwidth < 10% of center frequency	15 µV/m @ 30 m or bandwidth in (kHz) / f(MHz)	A	15.223
	Any	30 µV/m @ 30 m	Q	15.209
6.26775-6.26825 MHz	Swept frequency field disturbance sensors	30 µV/m @ 30 m	Q	15.205
6.26825-6.31175 MHz	Any, when 6 dB bandwidth ≥ 10% of center frequency	100 µV/m @ 30 m	A	15.223
	Any, when 6 dB bandwidth < 10% of center frequency	15 µV/m @ 30 m or bandwidth in (kHz) / f(MHz)	A	15.223
	Any	30 µV/m @ 30 m	Q	15.209
6.31175-6.31225 MHz	Swept frequency field disturbance sensors	30 µV/m @ 30 m	Q	15.205
6.31225-8.291 MHz	Any, when 6 dB bandwidth ≥ 10% of center frequency	100 µV/m @ 30 m	A	15.223
	Any, when 6 dB bandwidth < 10% of center frequency	15 µV/m @ 30 m or bandwidth in (kHz) / f(MHz)	A	15.223
	Any	30 µV/m @ 30 m	Q	15.209
8.291-8.294 MHz	Swept frequency field disturbance sensors	30 µV/m @ 30 m	Q	15.205
8.294-8.362 MHz	Any, when 6 dB bandwidth ≥ 10% of center frequency	100 µV/m @ 30 m	A	15.223
	Any, when 6 dB bandwidth < 10% of center frequency	15 µV/m @ 30 m or bandwidth in (kHz) / f(MHz)	A	15.223
	Any	30 µV/m @ 30 m	Q	15.209

8.362-8.366 MHz	Swept frequency field disturbance sensors	30 μV/m @ 30 m	Q	15.205
8.366-8.37625 MHz	Any, when 6 dB bandwidth ≥ 10% of center frequency	100 μV/m @ 30 m	A	15.223
	Any, when 6 dB bandwidth < 10% of center frequency	15 μV/m @ 30 m or bandwidth in (kHz) / f(MHz)	A	15.223
	Any	30 μV/m @ 30 m	Q	15.209
8.37625-8.38675 MHz	Swept frequency field disturbance sensors	30 μV/m @ 30 m	Q	15.205
8.38675-8.41425 MHz	Any, when 6 dB bandwidth ≥ 10% of center frequency	100 μV/m @ 30 m	A	15.223
8.38675-8.41425 MHz (cont.)	Any, when 6 dB bandwidth < 10% of center frequency	15 μV/m @ 30 m or bandwidth in (kHz) / f(MHz)	A	15.223
	Any	30 μV/m @ 30 m	Q	15.209
8.41425-8.41475 MHz	Swept frequency field disturbance sensors	30 μV/m @ 30 m	Q	15.205
8.41475-10 MHz	Any, when 6 dB bandwidth ≥ 10% of center frequency	100 μV/m @ 30 m	A	15.223
	Any, when 6 dB bandwidth < 10% of center frequency	15 μV/m @ 30 m or bandwidth in (kHz) / f(MHz)	A	15.223
	Any	30 μV/m @ 30 m	Q	15.209
10-12.29 MHz	Any	30 μV/m @ 30 m	Q	15.209
12.29-12.293 MHz	Swept frequency field disturbance sensors	30 μV/m @ 30 m	Q	15.205
12.293-12.51975 MHz	Any	30 μV/m @ 30 m	Q	15.209
12.51975-12.52025 MHz	Swept frequency field disturbance sensors	30 μV/m @ 30 m	Q	15.205
12.52025-12.57675 MHz	Any	30 μV/m @ 30 m	Q	15.209
12.57675-12.57725 MHz	Swept frequency field disturbance sensors	30 μV/m @ 30 m	Q	15.205
12.57725-13.36 MHz	Any	30 μV/m @ 30 m	Q	15.209
13.36-13.41 MHz	Swept frequency field disturbance sensors	30 μV/m @ 30 m	Q	15.205
13.41-13.553 MHz	Any	30 μV/m @ 30 m	Q	15.209

13.553-13.567 MHz	Any	10,000 µV/m @ 30 m	Q	15.225
	Any	30 µV/m @ 30 m	Q	15.209
13.567-16.42 MHz	Any	30 µV/m @ 30 m	Q	15.209
16.42-16.423 MHz	Swept frequency field disturbance sensors	30 µV/m @ 30 m	Q	15.205
16.423-16.69475 MHz	Any	30 µV/m @ 30 m	Q	15.209
16.69475-16.69525 MHz	Swept frequency field disturbance sensors	30 µV/m @ 30 m	Q	15.205
16.69525-16.80425 MHz	Any	30 µV/m @ 30 m	Q	15.209
16.80425-16.80475 MHz	Swept frequency field disturbance sensors	30 µV/m @ 30 m	Q	15.205
16.80475-25.5 MHz	Any	30 µV/m @ 30 m	Q	15.209
25.5-25.67 MHz	Swept frequency field disturbance sensors	30 µV/m @ 30 m	Q	15.205
25.67-26.96 MHz	Any	30 µV/m @ 30 m	Q	15.209
26.96-27.28 MHz	Any	10,000 µV/m @ 3 m	A	15.227
	Any	30 µV/m @ 30 m	Q	15.209
27.28-30 MHz	Any	30 µV/m @ 30 m	Q	15.209
30-37.5 MHz	Any	100 µV/m @ 3 m	Q	15.209
37.5-38.25 MHz	SPURIOUS EMISSIONS ONLY	100 µV/m @ 3 m	Q	15.205
38.25-40.66 MHz	Any	100 µV/m @ 3 m	Q	15.209
40.66-40.7 MHz	Intermittent Control Signals	2,250 µV/m @ 3 m	A or Q	15.231
	Periodic Transmissions	1,000 µV/m @ 3 m	A or Q	15.231
	Any	1,000 µV/m @ 3 m	Q	15.229
	Perimeter Protection Systems	500 µV/m @ 3 m	A	15.229
40.7-43.71 MHz	Any	100 µV/m @ 3 m	Q	15.209
43.71-44.49 MHz	Cordless Telephones	10,000 µV/m @ 3 m	A	15.233

	Any	100 µV/m @ 3 m	Q	15.209
44.49-46.6 MHz	Any	100 µV/m @ 3 m	Q	15.209
46.6-46.98 MHz	Cordless Telephones	10,000 µV/m @ 3 m	A	15.233
	Any	100 µV/m @ 3 m	Q	15.209
46.98-48.75 MHz	Any	100 µV/m @ 3 m	Q	15.209
48.75-49.51 MHz	Cordless Telephones	10,000 µV/m @ 3 m	A	15.233
	Any	100 µV/m @ 3 m	Q	15.209
49.51-49.66 MHz	Any	100 µV/m @ 3 m	Q	15.209
49.66-49.82 MHz	Cordless Telephones	10,000 µV/m @ 3 m	A	15.233
	Any	100 µV/m @ 3 m	Q	15.209
49.82-49.9 MHz	Any	10,000 µV/m @ 3 m	A	15.235
	Cordless Telephones	10,000 µV/m @ 3 m	A	15.233
49.9-50 MHz	Cordless Telephones	10,000 µV/m @ 3 m	A	15.233
	Any	100 µV/m @ 3 m	Q	15.209
50-54 MHz	Any	100 µV/m @ 3 m	Q	15.209
54-70 MHz	Non-Residential Perimeter Protection Systems	100 µV/m @ 3 m	Q	15.209
70-72 MHz	Intermittent Control Signals	1,250 µV/m @ 3 m	A or Q	15.231
	Periodic Transmissions	500 µV/m @ 3 m	A or Q	15.231
	Non-Residential Perimeter Protection Systems	100 µV/m @ 3 m	Q	15.209
72-73 MHz	Auditory Assistance Devices	80,000 µV/m @ 3 m	A	15.237
	Intermittent Control Signals	1,250 µV/m @ 3 m	A or Q	15.231
	Periodic Transmissions	500 µV/m @ 3 m	A or Q	15.231
	Any	100 µV/m @ 3 m	Q	15.209

73-74.6 MHz	SPURIOUS EMISSIONS ONLY	100 µV/m @ 3 m	Q	15.205
74.6-74.8 MHz	Auditory Assistance Devices	80,000 µV/m @ 3 m	A	15.237
	Intermittent Control Signals	1,250 µV/m @ 3 m	A or Q	15.231
	Periodic Transmissions	500 µV/m @ 3 m	A or Q	15.231
	Any	100 µV/m @ 3 m	Q	15.209
74.8-75.2 MHz	SPURIOUS EMISSIONS ONLY	100 µV/m @ 3 m	Q	15.205
75.2-76 MHz	Auditory Assistance Devices	80,000 µV/m @ 3 m	A	15.237
	Intermittent Control Signals	1,250 µV/m @ 3 m	A or Q	15.231
	Periodic Transmissions	500 µV/m @ 3 m	A or Q	15.231
	Any	100 µV/m @ 3 m	Q	15.209
76-88 MHz	Intermittent Control Signals	1,250 µV/m @ 3 m	A or Q	15.231
	Periodic Transmissions	500 µV/m @ 3 m	A or Q	15.231
	Non-Residential Perimeter Protection Systems	100 µV/m @ 3 m	Q	15.209
88-108 MHz	Intermittent Control Signals	1,250 µV/m @ 3 m	A or Q	15.231
	Periodic Transmissions	500 µV/m @ 3 m	A or Q	15.231
	Any (≤ 200 kHz bandwidth)	250 µV/m @ 3 m	A	15.239
	Any	150 µV/m @ 3 m	Q	15.209
108-121.94 MHz	SPURIOUS EMISSIONS ONLY	150 µV/m @ 3 m	Q	15.205
121.94-123 MHz	Intermittent Control Signals	1,250 µV/m @ 3 m	A or Q	15.231
	Periodic Transmissions	500 µV/m @ 3 m	A or Q	15.231
121.94-123 MHz (cont.)	Any	150 µV/m @ 3 m	Q	15.209
123-138 MHz	SPURIOUS EMISSIONS ONLY	150 µV/m @ 3 m	Q	15.205

138-149.9 MHz	Intermittent Control Signals	(625/11) x f(MHz) - (67500/11) µV/m @ 3 m	A or Q	15.231
	Periodic Transmissions	(250/11) x f(MHz) - (27000/11) µV/m @ 3 m	A or Q	15.231
	Any	150 µV/m @ 3 m	Q	15.209
149.9-150.05 MHz	SPURIOUS EMISSIONS ONLY	150 µV/m @ 3 m	Q	15.205
150.05-156.52475 MHz	Intermittent Control Signals	(625/11) x f(MHz) - (67500/11) µV/m @ 3 m	A or Q	15.231
	Periodic Transmissions	(250/11) x f(MHz) - (27000/11) µV/m @ 3 m	A or Q	15.231
	Any	150 µV/m @ 3 m	Q	15.209
156.52475-156.52525 MHz	SPURIOUS EMISSIONS ONLY	150 µV/m @ 3 m	Q	15.205
156.52525-156.7 MHz	Intermittent Control Signals	(625/11) x f(MHz) - (67500/11) µV/m @ 3 m	A or Q	15.231
	Periodic Transmissions	(250/11) x f(MHz) - (27000/11) µV/m @ 3 m	A or Q	15.231
	Any	150 µV/m @ 3 m	Q	15.209
156.7-156.9 MHz	SPURIOUS EMISSIONS ONLY	150 µV/m @ 3 m	Q	15.205
156.9-162.0125 MHz	Intermittent Control Signals	(625/11) x f(MHz) - (67500/11) µV/m @ 3 m	A or Q	15.231
	Periodic Transmissions	(250/11) x f(MHz) - (27000/11) µV/m @ 3 m	A or Q	15.231
156.9-162.0125 MHz (cont.)	Any	150 µV/m @ 3 m	Q	15.209
162.0125-167.17 MHz	SPURIOUS EMISSIONS ONLY	150 µV/m @ 3 m	Q	15.205
167.17-167.72 MHz	Intermittent Control Signals	(625/11) x f(MHz) - (67500/11) µV/m @ 3 m	A or Q	15.231
	Periodic Transmissions	(250/11) x f(MHz) - (27000/11) µV/m @ 3 m	A or Q	15.231
	Any	150 µV/m @ 3 m	Q	15.209

167.72-173.2 MHz	SPURIOUS EMISSIONS ONLY	150 μV/m @ 3 m	Q	15.205
173.2-174 MHz	Intermittent Control Signals	(625/11) x f(MHz) - (67500/11) μV/m @ 3 m	A or Q	15.231
	Periodic Transmissions	(250/11) x f(MHz) - (27000/11) μV/m @ 3 m	A or Q	15.231
	Any	150 μV/m @ 3 m	Q	15.209
174-216 MHz	Intermittent Control Signals	3,750 μV/m @ 3 m	A or Q	15.231
	Periodic Transmissions	1,500 μV/m @ 3 m	A or Q	15.231
	Biomedical Telemetry Devices	1,500 μV/m @ 3 m	A	15.241
216-240 MHz	Intermittent Control Signals	3,750 μV/m @ 3 m	A or Q	15.231
	Periodic Transmissions	1,500 μV/m @ 3 m	A or Q	15.231
	Any	200 μV/m @ 3 m	Q	15.209
240-285 MHz	SPURIOUS EMISSIONS ONLY	200 μV/m @ 3 m	Q	15.205
285-322 MHz	Intermittent Control Signals	(125/3) x f(MHz) - (21250/3) μV/m @ 3 m	A or Q	15.231
285-322 MHz (cont.)	Periodic Transmissions	(50/3) x f(MHz) - (8500/3) μV/m @ 3 m	A or Q	15.231
	Any	200 μV/m @ 3 m	Q	15.209
322-335.4 MHz	SPURIOUS EMISSIONS ONLY	200 μV/m @ 3 m	Q	15.205
335.4-399.9 MHz	Intermittent Control Signals	(125/3) x f(MHz) - (21250/3) μV/m @ 3 m	A or Q	15.231
	Periodic Transmissions	(50/3) x f(MHz) - (8500/3) μV/m @ 3 m	A or Q	15.231
	Any	200 μV/m @ 3 m	Q	15.209
399.9-410 MHz	SPURIOUS EMISSIONS ONLY	200 μV/m @ 3 m	Q	15.205
410-470 MHz	Intermittent Control Signals	(125/3) x f(MHz) - (21250/3) μV/m @ 3 m	A or Q	15.231

	Periodic Transmissions	(50/3) x f(MHz) - (8500/3) µV/m @ 3 m	A or Q	15.231
	Any	200 µV/m @ 3 m	Q	15.209
470-512 MHz	Intermittent Control Signals	12,500 µV/m @ 3 m	A or Q	15.231
	Periodic Transmissions	5,000 µV/m @ 3 m	A or Q	15.231
512-566 MHz	Intermittent Control Signals	12,500 µV/m @ 3 m	A or Q	15.231
	Periodic Transmissions	5,000 µV/m @ 3 m	A or Q	15.231
	Biomedical Telemetry Devices for Hospitals	200 µV/m @ 3 m	Q	15.209
566-608 MHz	Intermittent Control Signals	12,500 µV/m @ 3 m	A or Q	15.231
	Periodic Transmissions	5,000 µV/m @ 3 m	A or Q	15.231
608-614 MHz	SPURIOUS EMISSIONS ONLY	200 µV/m @ 3 m	Q	15.205
614-806 MHz	Intermittent Control Signals	12,500 µV/m @ 3 m	A or Q	15.231
	Periodic Transmissions	5,000 µV/m @ 3 m	A or Q	15.231
806-890 MHz	Intermittent Control Signals	12,500 µV/m @ 3 m	A or Q	15.231
	Periodic Transmissions	5,000 µV/m @ 3 m	A or Q	15.231
	Any	200 µV/m @ 3 m	Q	15.209
890-902 MHz	Intermittent Control Signals	12,500 µV/m @ 3 m	A or Q	15.231
	Periodic Transmissions	5,000 µV/m @ 3 m	A or Q	15.231
	Signals Used to Measure the Characteristics of a Material	500 µV/m @ 30 m	A	15.243
	Any	200 µV/m @ 3 m	Q	15.209
902-928 MHz	Spread Spectrum Transmitters	1 Watt Output Power		15.247
	Field Disturbance Sensors	500,000 µV/m @ 3 m	A	15.245
	Any	50,000 µV/m @ 3 m	Q	15.249

	Signals Used to Measure the Characteristics of a Material	500 µV/m @ 30 m	A	15.243
	Intermittent Control Signals	12,500 µV/m @ 3 m	A or Q	15.231
	Periodic Transmissions	5,000 µV/m @ 3 m	A or Q	15.231
928-940 MHz	Intermittent Control Signals	12,500 µV/m @ 3 m	A or Q	15.231
	Periodic Transmissions	5,000 µV/m @ 3 m	A or Q	15.231
	Signals Used to Measure the Characteristics of a Material	500 µV/m @ 30 m	A	15.243
928-940 MHz (cont.)	Any	200 µV/m @ 3 m	Q	15.209
940-960 MHz	Intermittent Control Signals	12,500 µV/m @ 3 m	A or Q	15.231
	Periodic Transmissions	5,000 µV/m @ 3 m	A or Q	15.231
	Any	200 µV/m @ 3 m	Q	15.209
960-1000 MHz	SPURIOUS EMISSIONS ONLY	500 µV/m @ 3 m	Q	15.205
1-1.24 GHz	SPURIOUS EMISSIONS ONLY	500 µV/m @ 3 m	A	15.205
1.24-1.3 GHz	Intermittent Control Signals	12,500 µV/m @ 3 m	A	15.231
	Periodic Transmissions	5,000 µV/m @ 3 m	A	15.231
	Any	500 µV/m @ 3 m	A	15.209
1.3-1.427 GHz	SPURIOUS EMISSIONS ONLY	500 µV/m @ 3 m	A	15.205
1.427-1.435 GHz	Intermittent Control Signals	12,500 µV/m @ 3 m	A	15.231
	Periodic Transmissions	5,000 µV/m @ 3 m	A	15.231
	Any	500 µV/m @ 3 m	A	15.209
1.435-1.6265 GHz	SPURIOUS EMISSIONS ONLY	500 µV/m @ 3 m	A	15.205
1.6265-1.6455 GHz	Intermittent Control Signals	12,500 µV/m @ 3 m	A	15.231
	Periodic Transmissions	5,000 µV/m @ 3 m	A	15.231
	Any	500 µV/m @ 3 m	A	15.209

1.6455-1.6465 GHz	SPURIOUS EMISSIONS ONLY	500 μV/m @ 3 m	A	15.205
1.6465-1.66 GHz	Intermittent Control Signals	12,500 μV/m @ 3 m	A	15.231
1.6465-1.66 GHz (cont.)	Periodic Transmissions	5,000 μV/m @ 3 m	A	15.231
	Any	500 μV/m @ 3 m	A	15.209
1.66-1.71 GHz	SPURIOUS EMISSIONS ONLY	500 μV/m @ 3 m	A	15.205
1.71-1.7188 GHz	Intermittent Control Signals	12,500 μV/m @ 3 m	A	15.231
	Periodic Transmissions	5,000 μV/m @ 3 m	A	15.231
	Any	500 μV/m @ 3 m	A	15.209
1.7188-1.7222 GHz	SPURIOUS EMISSIONS ONLY	500 μV/m @ 3 m	A	15.205
1.7222-2.2 GHz	Intermittent Control Signals	12,500 μV/m @ 3 m	A	15.231
	Periodic Transmissions	5,000 μV/m @ 3 m	A	15.231
	Any	500 μV/m @ 3 m	A	15.209
2.2-2.3 GHz	SPURIOUS EMISSIONS ONLY	500 μV/m @ 3 m	A	15.205
2.3-2.31 GHz	Intermittent Control Signals	12,500 μV/m @ 3 m	A	15.231
	Periodic Transmissions	5,000 μV/m @ 3 m	A	15.231
	Any	500 μV/m @ 3 m	A	15.209
2.31-2.39 GHz	SPURIOUS EMISSIONS ONLY	500 μV/m @ 3 m	A	15.205
2.39-2.4 GHz	Intermittent Control Signals	12,500 μV/m @ 3 m	A	15.231
	Periodic Transmissions	5,000 μV/m @ 3 m	A	15.231
	Any	500 μV/m @ 3 m	A	15.209
2.4-2.435 GHz	Spread Spectrum Transmitters	1 Watt Output Power		15.247
2.4-2.435 GHz (cont.)	Any	50,000 μV/m @ 3 m	A	15.249
2.435-2.465 GHz	Spread Spectrum Transmitters	1 Watt Output Power		15.247

	Field Disturbance Sensors	500,000 µV/m @ 3 m	A	15.245
	Any	50,000 µV/m @ 3 m	A	15.249
2.465-2.4835 GHz	Spread Spectrum Transmitters	1 Watt Output Power		15.247
	Any	50,000 µV/m @ 3 m	A	15.249
2.4835-2.5 GHz	SPURIOUS EMISSIONS ONLY	500 µV/m @ 3 m	A	15.205
2.5-2.655 GHz	Intermittent Control Signals	12,500 µV/m @ 3 m	A	15.231
	Periodic Transmissions	5,000 µV/m @ 3 m	A	15.231
	Any	500 µV/m @ 3 m	A	15.209
2.655-2.9 GHz	SPURIOUS EMISSIONS ONLY	500 µV/m @ 3 m	A	15.205
2.9-3.26 GHz	Intermittent Control Signals	12,500 µV/m @ 3 m	A	15.231
	Periodic Transmissions	5,000 µV/m @ 3 m	A	15.231
	Automatic Vehicle Identification Systems	3,000 µV/m per MHz of bandwidth @ 3 m	A	15.251
	Any	500 µV/m @ 3 m	A	15.209
3.26-3.267 GHz	SPURIOUS EMISSIONS ONLY	500 µV/m @ 3 m	A	15.205
3.267-3.332 GHz	Intermittent Control Signals	12,500 µV/m @ 3 m	A	15.231
	Periodic Transmissions	5,000 µV/m @ 3 m	A	15.231
	Automatic Vehicle Identification Systems	3,000 µV/m per MHz of bandwidth @ 3 m	A	15.251
3.267-3.332 GHz (cont.)	Any	500 µV/m @ 3 m	A	15.209
3.332-3.339 GHz	SPURIOUS EMISSIONS ONLY	500 µV/m @ 3 m	A	15.205
3.339-3.3458 GHz	Intermittent Control Signals	12,500 µV/m @ 3 m	A	15.231
	Periodic Transmissions	5,000 µV/m @ 3 m	A	15.231
	Automatic Vehicle Identification Systems	3,000 µV/m per MHz of bandwidth @ 3 m	A	15.251
	Any	500 µV/m @ 3 m	A	15.209

3.3458-3.358 GHz	SPURIOUS EMISSIONS ONLY	500 µV/m @ 3 m	A	15.205
3.358-3.6 GHz	Intermittent Control Signals	12,500 µV/m @ 3 m	A	15.231
	Periodic Transmissions	5,000 µV/m @ 3 m	A	15.231
	Automatic Vehicle Identification Systems	3,000 µV/m per MHz of bandwidth @ 3 m	A	15.251
	Any	500 µV/m @ 3 m	A	15.209
3.6-4.4 GHz	SPURIOUS EMISSIONS ONLY	500 µV/m @ 3 m	A	15.205
4.4-4.5 GHz	Intermittent Control Signals	12,500 µV/m @ 3 m	A	15.231
	Periodic Transmissions	5,000 µV/m @ 3 m	A	15.231
	Any	500 µV/m @ 3 m	A	15.209
4.5-5.25 GHz	SPURIOUS EMISSIONS ONLY	500 µV/m @ 3 m	A	15.205
5.25-5.35 GHz	Intermittent Control Signals	12,500 µV/m @ 3 m	A	15.231
	Periodic Transmissions	5,000 µV/m @ 3 m	A	15.231
	Any	500 µV/m @ 3 m	A	15.209
5.35-5.46 GHz	SPURIOUS EMISSIONS ONLY	500 µV/m @ 3 m	A	15.205
5.46-5.725 GHz	Intermittent Control Signals	12,500 µV/m @ 3 m	A	15.231
	Periodic Transmissions	5,000 µV/m @ 3 m	A	15.231
	Any	500 µV/m @ 3 m	A	15.209
5.725-5.785 GHz	Spread Spectrum Transmitters	1 Watt Output Power		15.247
	Any	50,000 µV/m @ 3 m	A	15.249
5.785-5.815 GHz	Spread Spectrum Transmitters	1 Watt Output Power		15.247
	Field Disturbance Sensors	500,000 µV/m @ 3 m	A	15.245
	Any	50,000 µV/m @ 3 m	A	15.249
5.815-5.85 GHz	Spread Spectrum Transmitters	1 Watt Output Power		15.247

	Any	50,000 µV/m @ 3 m	A	15.249
5.85-5.875 GHz	Any	50,000 µV/m @ 3 m	A	15.249
5.875-7.25 GHz	Intermittent Control Signals	12,500 µV/m @ 3 m	A	15.231
	Periodic Transmissions	5,000 µV/m @ 3 m	A	15.231
	Any	500 µV/m @ 3 m	A	15.209
7.25-7.75 GHz	SPURIOUS EMISSIONS ONLY	500 µV/m @ 3 m	A	15.205
7.75-8.025 GHz	Intermittent Control Signals	12,500 µV/m @ 3 m	A	15.231
	Periodic Transmissions	5,000 µV/m @ 3 m	A	15.231
	Any	500 µV/m @ 3 m	A	15.209
8.025-8.5 GHz	SPURIOUS EMISSIONS ONLY	500 µV/m @ 3 m	A	15.205
8.5-9 GHz	Intermittent Control Signals	12,500 µV/m @ 3 m	A	15.231
	Periodic Transmissions	5,000 µV/m @ 3 m	A	15.231
	Any	500 µV/m @ 3 m	A	15.209
9-9.2 GHz	SPURIOUS EMISSIONS ONLY	500 µV/m @ 3 m	A	15.205
9.2-9.3 GHz	Intermittent Control Signals	12,500 µV/m @ 3 m	A	15.231
	Periodic Transmissions	5,000 µV/m @ 3 m	A	15.231
	Any	500 µV/m @ 3 m	A	15.209
9.3-9.5 GHz	SPURIOUS EMISSIONS ONLY	500 µV/m @ 3 m	A	15.205
9.5-10.5 GHz	Intermittent Control Signals	12,500 µV/m @ 3 m	A	15.231
	Periodic Transmissions	5,000 µV/m @ 3 m	A	15.231
	Any	500 µV/m @ 3 m	A	15.209
10.5-10.55 GHz	Field Disturbance Sensors	2,500,000 µV/m @ 3 m	A	15.245
	Intermittent Control Signals	12,500 µV/m @ 3 m	A	15.231

	Periodic Transmissions	5,000 µV/m @ 3 m	A	15.231
	Any	500 µV/m @ 3 m	A	15.209
10.55-10.6 GHz	Intermittent Control Signals	12,500 µV/m @ 3 m	A	15.231
	Periodic Transmissions	5,000 µV/m @ 3 m	A	15.231
	Any	500 µV/m @ 3 m	A	15.209
10.6-12.7 GHz	SPURIOUS EMISSIONS ONLY	500 µV/m @ 3 m	A	15.205
12.7-13.25 GHz	Intermittent Control Signals	12,500 µV/m @ 3 m	A	15.231
	Periodic Transmissions	5,000 µV/m @ 3 m	A	15.231
	Any	500 µV/m @ 3 m	A	15.209
13.25-13.4 GHz	SPURIOUS EMISSIONS ONLY	500 µV/m @ 3 m	A	15.205
13.4-14.47 GHz	Intermittent Control Signals	12,500 µV/m @ 3 m	A	15.231
	Periodic Transmissions	5,000 µV/m @ 3 m	A	15.231
	Any	500 µV/m @ 3 m	A	15.209
14.47-14.5 GHz	SPURIOUS EMISSIONS ONLY	500 µV/m @ 3 m	A	15.205
14.5-15.35 GHz	Intermittent Control Signals	12,500 µV/m @ 3 m	A	15.231
	Periodic Transmissions	5,000 µV/m @ 3 m	A	15.231
	Any	500 µV/m @ 3 m	A	15.209
15.35-16.2 GHz	SPURIOUS EMISSIONS ONLY	500 µV/m @ 3 m	A	15.205
16.2-17.7 GHz	Intermittent Control Signals	12,500 µV/m @ 3 m	A	15.231
	Periodic Transmissions	5,000 µV/m @ 3 m	A	15.231
	Any	500 µV/m @ 3 m	A	15.209
17.7-21.4 GHz	SPURIOUS EMISSIONS ONLY	500 µV/m @ 3 m with higher emissions permitted according to Section 15.205(d)	A	15.205

21.4-22.01 GHz	Intermittent Control Signals	12,500 µV/m @ 3 m	A	15.231
21.4-22.01 GHz (cont.)	Periodic Transmissions	5,000 µV/m @ 3 m	A	15.231
	Any	500 µV/m @ 3 m	A	15.209
22.01-23.12 GHz	SPURIOUS EMISSIONS ONLY	500 µV/m @ 3 m with higher emissions permitted according to Section 15.205(d)	A	15.205
23.12-23.6 GHz	Intermittent Control Signals	12,500 µV/m @ 3 m	A	15.231
	Periodic Transmissions	5,000 µV/m @ 3 m	A	15.231
	Any	500 µV/m @ 3 m	A	15.209
23.6-24 GHz	SPURIOUS EMISSIONS ONLY	500 µV/m @ 3 m with higher emissions permitted according to Section 15.205(d)	A	15.205
24-24.075 GHz	Any	250,000 µV/m @ 3 m	A	15.249
24.075-24.175 GHz	Field Disturbance Sensors	2,500,000 µV/m @ 3 m	A	15.245
	Any	250,000 µV/m @ 3 m	A	15.249
24.175-24.25 GHz	Any	250,000 µV/m @ 3 m	A	15.249
24.25-31.2 GHz	Intermittent Control Signals	12,500 µV/m @ 3 m	A	15.231
	Periodic Transmissions	5,000 µV/m @ 3 m	A	15.231
	Any	500 µV/m @ 3 m	A	15.209
31.2-31.8 GHz	SPURIOUS EMISSIONS ONLY	500 µV/m @ 3 m with higher emissions permitted according to Section 15.205(d)	A	15.205
31.8-36.43 GHz	Intermittent Control Signals	12,500 µV/m @ 3 m	A	15.231
31.8-36.43 GHz (cont.)	Periodic Transmissions	5,000 µV/m @ 3 m	A	15.231
	Any	500 µV/m @ 3 m	A	15.209
36.43-36.5 GHz	SPURIOUS EMISSIONS ONLY	500 µV/m @ 3 m with higher emissions permitted according to Section 15.205(d)	A	15.205

36.5-38.6 GHz	Intermittent Control Signals	12,500 μV/m @ 3 m	A	15.231
	Periodic Transmissions	5,000 μV/m @ 3 m	A	15.231
	Any	500 μV/m @ 3 m	A	15.209
Above 38.6 GHz	SPURIOUS EMISSIONS ONLY	500 μV/m @ 3 m with higher emissions permitted according to Section 15.205(d)	A	15.205

Cordless telephones

Cordless telephones are required to incorporate circuitry that uses digital security codes to help prevent the phone from unintentionally connecting to the public switched telephone network when it encounters radio frequency noise from another cordless phone or from some other source. Cordless phones that do not have this circuitry (phones that were manufactured or imported prior to September 11, 1991) are required to have a statement on the package in which they are sold that warns of the danger of unintentional line seizures and indicates what features the packaged phone has to help prevent them. Section 15.214

The preceding table describes the frequencies that cordless phones can use.

Tunnel radio systems

Many tunnels have naturally surrounding earth and/or water that attenuates radio waves. Transmitters that are operated inside these tunnels are not subject to any radiation limits inside the tunnel. Instead, the signals they produce must meet the Part 15 general radiated emission limits on the outside of the tunnel, including its openings. They also must comply with the conducted emission limits on the electric power lines outside of the tunnel. Section 15.211

Buildings and other structures that are not surrounded by earth or water (e.g. oil storage tanks) are not tunnels. Transmitters that are operated inside such structures are subject to the same standards as transmitters operated in an open area.

<u>Commonly Asked Questions</u>

What happens if one sells, imports or uses non-compliant low-power transmitters?

The FCC rules are designed to control the marketing of low-power transmitters and, to a lesser extent, their use. If the operation of a non-compliant transmitter causes interference to authorized radio communications, the user should stop operating the transmitter or correct the problem causing the interference. However, the person (or company) that sold this non-compliant transmitter to the user has violated the FCC marketing rules in Part 2 as well as federal law. The act of selling or leasing, offering to sell or lease, or importing a low-power transmitter that has not gone through the appropriate FCC equipment authorization procedure is a violation of the Commission's rules and federal law. Violators may be subject to an enforcement action by the Commission's Field Operations Bureau that could result in:

Section 15.1
Section 15.5
Section 2.803
Section 2.805
Section 2.1203

- o forfeiture of all non-compliant equipment
- o \$100,000/\$200,000 criminal penalty for an individual/organization
- o a criminal fine totalling twice the gross gain obtained from sales of the non-compliant equipment
- o an administrative fine totalling \$10,000/day per violation, up to a maximum of \$75,000

Section 1.80
47 U.S.C. 302
47 U.S.C. 501
47 U.S.C. 502
47 U.S.C. 503
47 U.S.C. 510
18 U.S.C. 3571

What changes can be made to an FCC-authorized device without requiring a new FCC

authorization?

The person or company that obtained FCC authorization for a Part 15 transmitter is permitted to make the following types of changes:

For **certified equipment,** the holder of the grant of certification, or the holder's agent, can make minor modifications to the circuitry, appearance or other design aspects of the transmitter. Minor modifications are divided into two categories: Class I permissive changes and Class II permissive changes. Major changes are not permitted. Section 2.929 Section 2.1043

> Minor changes that do not increase the radio frequency emissions from the transmitter do not require the grantee to file any information with the FCC. These are called ***Class I permissive changes***. (Note: if a Class I permissive change results in a product that looks different than the one that was certified it is strongly suggested that photos of the modified transmitter be filed with the FCC.)
>
> Minor changes that increase the radio frequency emissions from the transmitter require the grantee to file complete information about the change along with results of tests showing that the equipment continues to comply with FCC technical standards. In this case, the modified equipment may not be marketed under the existing grant of certification prior to acknowledgement by the Commission that the change is acceptable. These are called ***Class II permissive changes***.
>
> Major changes require that a new grant be obtained by submitting a new application with complete test results. Some examples of major changes include: changes to the basic frequency determining and stabilizing circuitry; changes to the frequency multiplication stages or basic modulator circuit; and, major changes to the size, shape or shielding properties of the case.

No changes are permitted to certified equipment by anyone other than the grantee or the grantee's designated agent; except, however, that changes to the FCC ID without any other changes to the equipment may be performed by anyone by filing an abbreviated application. Section 2.1043 Section 2.933

For **verified equipment**, any changes may be made to the circuitry, appearance or other design aspects of the device as long as the manufacturer (importer, if the equipment is imported) has on file updated circuit drawings and test data showing that the equipment continues to comply with the FCC rules. Section 2.952 Section 2.953 Section 2.955

What is the relationship between "microvolts per meter" and Watts?

Watts are the units used to describe the amount of power generated by a transmitter. Microvolts per meter (µV/m) are the units used to describe the strength of an electric field created by the operation of a transmitter.

A particular transmitter that generates a constant level of power (Watts) can produce electric fields of different strengths (µV/m) depending on, among other things, the type of transmission line and antenna connected to it. Because it is the electric field that causes interference to authorized radio communications, and since a particular electric field strength does not directly correspond to a particular level of transmitter power, most of the Part 15 emission limits are specified in field strength.

Although the precise relationship between power and field strength can depend on a number of additional factors, a commonly-used equation to approximate their relationship is:

$$\frac{PG}{4\pi D^{2}} = \frac{E^{2}}{120\pi}$$

where: P is transmitter power in Watts;
G is the numerical gain of the transmitting antenna relative to an isotropic source;
D is the distance of the measuring point from the electrical center of the antenna in meters; and,
E is field strength in volts/meter.

4BD^{2} is the surface area of the sphere centered at the radiating source whose surface is D meters from the radiating source. 120B is the characteristic impedance of free space in ohms.

Using this equation, and assuming a unity gain antenna (G = 1) and a measurement distance of 3 meters (D = 3), a formula for determining power given field strength can be developed:

$$P = 0.3E^{2}$$

where: P is the transmitter power (EIRP) in watts and E is the field strength in volts/meter.

Additional Information

Obtaining rules

The FCC rules are contained in *Title 47 of the Code of Federal Regulations* (47 CFR). Parts 2 and 15 are applicable to low-power transmitters. Part 68 applies, in addition, to equipment that connects to the public switched telephone network. To obtain a copy of these rules contact:

Superintendent of Documents
U.S. Government Printing Office
P.O. Box 371954
Pittsburgh, PA 15250-7954

Tel: (202) 512-1800 / Fax: (202) 512-2250
(8 AM - 5 PM Eastern Time)
(GPO deposit accounts, VISA and MasterCard accepted)

Obtaining forms and fee filing guides

To obtain copies of FCC Form 159 ("Fee Advice Form"), FCC Form 731 ("Application for Equipment Authorization") FCC Form 730 ("Registration of Telephone and Data Terminal Equipment"), and fee filing guides contact:

Federal Communications Commission
Forms Distribution Center
9300 E. Hampton Drive
Capitol Heights, MD 20743
Tel: (202) 418-3676 or 1-800 418-3676

Equipment authorization procedures

Questions regarding equipment authorization procedures for Part 15 transmitters should be addressed to:

Federal Communications Commission
Equipment Authorization Division
Application Processing Branch, MS 1300F1
7435 Oakland Mills Road
Columbia, MD 21046
Tel: (301) 725-1585 / Fax: (301) 344-2050
E-Mail: labinfo@fcc.gov

Obtaining equipment authorization filing packets

Application packets to assist applicants in applying for certification of transmitters and obtaining a grantee code are available from:

Federal Communications Commission
Equipment Authorization Division
Customer Service Branch
Tel: (301) 725-1585, Ext 639 / Fax: (301) 344-2050
E-Mail: labinfo@fcc.gov

Rule interpretations

Questions regarding interpretations of the Part 2 and Part 15 rules as they apply to low-power transmitters and measurement procedures used to test these transmitters for compliance with the Part 15 technical standards, should be addressed to:

Federal Communications Commission
Equipment Authorization Division
Customer Service Branch, MS 1300F2
7435 Oakland Mills Road
Columbia, MD 21046
Tel: (301) 725-1585 / Fax: (301) 344-2050
E-Mail: labinfo@fcc.gov

Part 68 registration requirements

Questions regarding the Part 68 rules as they apply to equipment that connects to the public switched telephone network (cordless phones, wireless modems etc.) should be addressed to:

Federal Communications Commission
Network Services Division, MS 1600B
Washington, DC 20554
Tel: (202) 418-2342 / Fax: (202) 418-2345

Experimental licenses

Prior to obtaining FCC equipment authorization, Part 15 transmitters may not be operated without an experimental license; *except*, however, that no license is needed to test a Part 15 transmitter for compliance with the FCC rules. Information on obtaining an experimental license may be obtained from:

Federal Communications Commission
New Technology Development Division
Experimental Licensing Branch, MS 1300E1
Washington, DC 20554
Tel: (202) 418-2479 / Fax: (202) 418-1918

FCC's computer bulletin board

The FCC maintains a computer bulletin board, called the Public Access Link (PAL), that contains information about the FCC rules, proposed or recent rule changes, application procedures, fees and equipment authorizations. Applicants may check on the status of their applications, and others may check the validity of an FCC ID on a piece of equipment, by dialing this bulletin board via computer modem at:

(301) 725-1072
Modem set up: 8 bits, no parity, 1 stop bit
(parity is ignored on input and system does not send parity on output)

Status desk

Applicants who do not have access to a computer may check on the status of their applications by calling the Equipment Authorization Division's status desk at:

(301) 725-1585, Ext. 300 (Monday-Thursday, 2:00 - 4:30 PM)

Title 47: Telecommunication – Updated September 2014

PART 97—AMATEUR RADIO SERVICE

Subpart A—General Provisions

§97.1 Basis and purpose.

The rules and regulations in this part are designed to provide an amateur radio service having a fundamental purpose as expressed in the following principles:

(a) Recognition and enhancement of the value of the amateur service to the public as a voluntary noncommercial communication service, particularly with respect to providing emergency communications.

(b) Continuation and extension of the amateur's proven ability to contribute to the advancement of the radio art.

(c) Encouragement and improvement of the amateur service through rules which provide for advancing skills in both the communication and technical phases of the art.

(d) Expansion of the existing reservoir within the amateur radio service of trained operators, technicians, and electronics experts.

(e) Continuation and extension of the amateur's unique ability to enhance international goodwill.

§97.3 Definitions.

(a) The definitions of terms used in part 97 are:

(1) *Amateur operator.* A person named in an amateur operator/primary license station grant on the ULS consolidated licensee database to be the control operator of an amateur station.

(2) *Amateur radio services.* The amateur service, the amateur-satellite service and the radio amateur civil emergency service.

(4) *Amateur service.* A radiocommunication service for the purpose of self-training, intercommunication and technical investigations carried out by amateurs, that is, duly authorized persons interested in radio technique solely with a personal aim and without pecuniary interest.

(5) *Amateur station.* A station in an amateur radio service consisting of the apparatus necessary for carrying on radiocommunications.

(6) *Automatic control.* The use of devices and procedures for control of a station when it is transmitting so that compliance with the FCC Rules is achieved without the control operator being present at a control point.

(7) *Auxiliary station.* An amateur station, other than in a message forwarding system, that is transmitting communications point-to-point within a system of cooperating amateur stations.

(8) *Bandwidth.* The width of a frequency band outside of which the mean power of the transmitted signal is attenuated at least 26 dB below the mean power of the transmitted signal within the band.

(9) *Beacon.* An amateur station transmitting communications for the purposes of observation of propagation and reception or other related experimental activities.

(10) *Broadcasting.* Transmissions intended for reception by the general public, either direct or relayed.

(11) *Call sign system.* The method used to select a call sign for amateur station over-the-air identification purposes. The call sign systems are:

(i) *Sequential call sign system.* The call sign is selected by the FCC from an alphabetized list corresponding to the geographic region of the licensee's mailing address and operator class. The call sign is shown on the license. The FCC will issue public announcements detailing the procedures of the sequential call sign system.

(ii) *Vanity call sign system.* The call sign is selected by the FCC from a list of call signs requested by the licensee. The call sign is shown on the license. The FCC will issue public announcements detailing the procedures of the vanity call sign system.

(iii) *Special event call sign system.* The call sign is selected by the station licensee from a list of call signs shown on a common data base coordinated, maintained and disseminated by the amateur station special event call sign data base coordinators. The call sign must have the single

letter prefix K, N or W, followed by a single numeral 0 through 9, followed by a single letter A through W or Y or Z (for example K1A). The special event call sign is substituted for the call sign shown on the station license grant while the station is transmitting. The FCC will issue public announcements detailing the procedures of the special event call sign system.

(12) *CEPT radio amateur license.* A license issued by a country belonging to the European Conference of Postal and Telecommunications Administrations (CEPT) that has adopted Recommendation T/R 61-01 (Nice 1985, Paris 1992, Nicosia 2003).

(13) *Control operator.* An amateur operator designated by the licensee of a station to be responsible for the transmissions from that station to assure compliance with the FCC Rules.

(14) *Control point.* The location at which the control operator function is performed.

(15) *CSCE.* Certificate of successful completion of an examination.

(16) *Earth station.* An amateur station located on, or within 50 km of, the Earth's surface intended for communications with space stations or with other Earth stations by means of one or more other objects in space.

(17) [Reserved]

(18) *External RF power amplifier.* A device capable of increasing power output when used in conjunction with, but not an integral part of, a transmitter.

(19) [Reserved]

(20) *FAA.* Federal Aviation Administration.

(21) *FCC.* Federal Communications Commission.

(22) *Frequency coordinator.* An entity, recognized in a local or regional area by amateur operators whose stations are eligible to be auxiliary or repeater stations, that recommends transmit/receive channels and associated operating and technical parameters for such stations in order to avoid or minimize potential interference.

(23) *Harmful interference.* Interference which endangers the functioning of a radionavigation service or of other safety services or seriously degrades, obstructs or repeatedly interrupts a radiocommunication service operating in accordance with the Radio Regulations.

(24) *IARP (International Amateur Radio Permit).* A document issued pursuant to the terms of the Inter-American Convention on an International Amateur Radio Permit by a country signatory to that Convention, other than the United States. Montrouis, Haiti. AG/doc.3216/95.

(25) *Indicator.* Words, letters or numerals appended to and separated from the call sign during the station identification.

(26) *Information bulletin.* A message directed only to amateur operators consisting solely of subject matter of direct interest to the amateur service.

(27) *In-law.* A parent, stepparent, sibling, or step-sibling of a licensee's spouse; the spouse of a licensee's sibling, step-sibling, child, or stepchild; or the spouse of a licensee's spouse's sibling or step-sibling.

(28) *International Morse code.* A dot-dash code as defined in ITU-T Recommendation F.1 (March, 1998), Division B, I. Morse code.

(29) *ITU.* International Telecommunication Union.

(30) *Line A.* Begins at Aberdeen, WA, running by great circle arc to the intersection of 48° N, 120° W, thence along parallel 48° N, to the intersection of 95° W, thence by great circle arc through the southernmost point of Duluth, MN, thence by great circle arc to 45° N, 85° W, thence southward along meridian 85° W, to its intersection with parallel 41° N, thence along parallel 41° N, to its intersection with meridian 82° W, thence by great circle arc through the southernmost point of Bangor, ME, thence by great circle arc through the southernmost point of Searsport, ME, at which point it terminates.

(31) *Local control.* The use of a control operator who directly manipulates the operating adjustments in the station to achieve compliance with the FCC Rules.

(32) *Message forwarding system.* A group of amateur stations participating in a voluntary, cooperative, interactive arrangement where communications are sent from the control operator of an originating station to the control operator of one or more destination stations by one or more forwarding stations.

(33) *National Radio Quiet Zone.* The area in Maryland, Virginia and West Virginia Bounded by 39°15′ N on the north, 78°30′ W on the east, 37°30′ N on the south and 80°30′ W on the west.

(34) *Physician.* For the purpose of this part, a person who is licensed to practice in a place where the amateur service is regulated by the FCC, as either a Doctor of Medicine (M.D.) or a Doctor of Osteopathy (D.O.)

(35) *Question pool.* All current examination questions for a designated written examination element.

(36) *Question set.* A series of examination questions on a given examination selected from the question pool.

(37) *Radio Regulations.* The latest ITU *Radio Regulations* to which the United States is a party.

(38) *RACES* (radio amateur civil emergency service). A radio service using amateur stations for civil defense communications during periods of local, regional or national civil emergencies.

(39) *Remote control.* The use of a control operator who indirectly manipulates the operating adjustments in the station through a control link to achieve compliance with the FCC Rules.

(40) *Repeater.* An amateur station that simultaneously retransmits the transmission of another amateur station on a different channel or channels.

(41) *Space station.* An amateur station located more than 50 km above the Earth's surface.

(42) *Space telemetry.* A one-way transmission from a space station of measurements made from the measuring instruments in a spacecraft, including those relating to the functioning of the spacecraft.

(43) *Spurious emission.* An emission, or frequencies outside the necessary bandwidth of a transmission, the level of which may be reduced without affecting the information being transmitted.

(44) *Telecommand.* A one-way transmission to initiate, modify, or terminate functions of a device at a distance.

(45) *Telecommand station.* An amateur station that transmits communications to initiate, modify or terminate functions of a space station.

(46) *Telemetry.* A one-way transmission of measurements at a distance from the measuring instrument.

(47) *Third party communications.* A message from the control operator (first party) of an amateur station to another amateur station control operator (second party) on behalf of another person (third party).

(48) *ULS (Universal Licensing System).* The consolidated database, application filing system and processing system for all Wireless Telecommunications Services.

(49) *VE.* Volunteer examiner.

(50) *VEC.* Volunteer-examiner coordinator.

(b) The definitions of technical symbols used in this part are:

(1) *EHF* (extremely high frequency). The frequency range 30-300 GHz.

(2) *HF* (high frequency). The frequency range 3-30 MHz.

(3) *Hz.* Hertz.

(4) *m.* Meters.

(5) *MF* (medium frequency). The frequency range 300-3000 kHz.

(6) *PEP* (peak envelope power). The average power supplied to the antenna transmission line by a transmitter during one RF cycle at the crest of the modulation envelope taken under normal operating conditions.

(7) *RF.* Radio frequency.

(8) *SHF* (super-high frequency). The frequency range 3-30 GHz.

(9) *UHF* (ultra-high frequency). The frequency range 300-3000 MHz.

(10) *VHF* (very-high frequency). The frequency range 30-300 MHz.

(11) *W.* Watts.

(c) The following terms are used in this part to indicate emission types. Refer to §2.201 of the FCC Rules, *Emission, modulation and transmission characteristics,* for information on emission type designators.

(1) *CW.* International Morse code telegraphy emissions having designators with A, C, H, J or R as the first symbol; 1 as the second symbol; A or B as the third symbol; and emissions J2A and J2B.

(2) *Data.* Telemetry, telecommand and computer communications emissions having (i) designators with A, C, D, F, G, H, J or R as the first symbol, 1 as the second symbol, and D as the third symbol; (ii) emission J2D; and (iii) emissions A1C, F1C, F2C, J2C, and J3C having an occupied bandwidth of 500 Hz or less when transmitted on an amateur service frequency below 30 MHz. Only a digital code of a type specifically authorized in this part may be transmitted.

(3) *Image.* Facsimile and television emissions having designators with A, C, D, F, G, H, J or R as the first symbol; 1, 2 or 3 as the second symbol; C or F as the third symbol; and emissions having B as the first symbol; 7, 8 or 9 as the second symbol; W as the third symbol.

(4) *MCW.* Tone-modulated international Morse code telegraphy emissions having designators with A, C, D, F, G, H or R as the first symbol; 2 as the second symbol; A or B as the third symbol.

(5) *Phone.* Speech and other sound emissions having designators with A, C, D, F, G, H, J or R as the first symbol; 1, 2, 3 or X as the second symbol; E as the third symbol. Also speech emissions having B or F as the first symbol; 7, 8 or 9 as the second symbol; E as the third symbol. MCW for the purpose of performing the station identification procedure, or for providing telegraphy practice interspersed with speech. Incidental tones for the purpose of selective calling or alerting or to control the level of a demodulated signal may also be considered phone.

(6) *Pulse.* Emissions having designators with K, L, M, P, Q, V or W as the first symbol; 0, 1, 2, 3, 7, 8, 9 or X as the second symbol; A, B, C, D, E, F, N, W or X as the third symbol.

(7) *RTTY.* Narrow-band direct-printing telegraphy emissions having designators with A, C, D, F, G, H, J or R as the first symbol; 1 as the second symbol; B as the third symbol; and emission J2B. Only a digital code of a type specifically authorized in this part may be transmitted.

(8) *SS.* Spread spectrum emissions using bandwidth-expansion modulation emissions having designators with A, C, D, F, G, H, J or R as the first symbol; X as the second symbol; X as the third symbol.

(9) *Test.* Emissions containing no information having the designators with N as the third symbol. Test does not include pulse emissions with no information or modulation unless pulse emissions are also authorized in the frequency band.

[54 FR 25857, June 20, 1989]

EDITORIAL NOTE: For FEDERAL REGISTER citations affecting §97.3, see the List of CFR Sections Affected, which appears in the Finding Aids section of the printed volume and at *www.fdsys.gov.*

§97.5 Station license required.

(a) The station apparatus must be under the physical control of a person named in an amateur station license grant on the ULS consolidated license database or a person authorized for alien reciprocal operation by §97.107 of this part, before the station may transmit on any amateur service frequency from any place that is:

(1) Within 50 km of the Earth's surface and at a place where the amateur service is regulated by the FCC;

(2) Within 50 km of the Earth's surface and aboard any vessel or craft that is documented or registered in the United States; or

(3) More than 50 km above the Earth's surface aboard any craft that is documented or registered in the United States.

(b) The types of station license grants are:

(1) *An operator/primary station license grant.* One, but only one, operator/primary station license grant may be held by any one person. The primary station license is granted together with the amateur operator license. Except for a representative of a foreign government, any person who qualifies by examination is eligible to apply for an operator/primary station license grant.

(2) *A club station license grant.* A club station license grant may be held only by the person who is the license trustee designated by an officer of the club. The trustee must be a person who holds an operator/primary station license grant. The club must be composed of at least four persons and must have a name, a document of organization, management, and a primary purpose devoted to amateur service activities consistent with this part.

(3) *A military recreation station license grant.* A military recreation station license grant may be held only by the person who is the license custodian designated by the official in charge of the United States military recreational premises where the station is situated. The person must not be a representative of a foreign government. The person need not hold an amateur operator license grant.

(c) The person named in the station license grant or who is authorized for alien reciprocal operation by §97.107 of this part may use, in accordance with the applicable rules of this part, the transmitting apparatus under the physical control of the person at places where the amateur service is regulated by the FCC.

(d) A CEPT radio-amateur license is issued to the person by the country of which the person is a citizen. The person must not:

(1) Be a resident alien or citizen of the United States, regardless of any other citizenship also held;

(2) Hold an FCC-issued amateur operator license nor reciprocal permit for alien amateur licensee;

(3) Be a prior amateur service licensee whose FCC-issued license was revoked, suspended for less than the balance of the license term and the suspension is still in effect, suspended for the balance of the license term and relicensing has not taken place, or surrendered for cancellation following notice of revocation, suspension or monetary forfeiture proceedings; or

(4) Be the subject of a cease and desist order that relates to amateur service operation and which is still in effect.

(e) An IARP is issued to the person by the country of which the person is a citizen. The person must not:

(1) Be a resident alien or citizen of the United States, regardless of any other citizenship also held;

(2) Hold an FCC-issued amateur operator license nor reciprocal permit for alien amateur licensee;

(3) Be a prior amateur service licensee whose FCC-issued license was revoked, suspended for less than the balance of the license term and the suspension is still in effect, suspended for the balance of the license term and relicensing has not taken place, or surrendered for cancellation following notice of revocation, suspension or monetary forfeiture proceedings; or

(4) Be the subject of a cease and desist order that relates to amateur service operation and which is still in effect.

[59 FR 54831, Nov. 2, 1994, as amended at 62 FR 17567, Apr. 10, 1997; 63 FR 68977, Dec. 14, 1998; 75 FR 78169, Dec. 15, 2010]

§97.7 Control operator required.

When transmitting, each amateur station must have a control operator. The control operator must be a person:

(a) For whom an amateur operator/primary station license grant appears on the ULS consolidated licensee database, or

(b) Who is authorized for alien reciprocal operation by §97.107 of this part.

[63 FR 68978, Dec. 14, 1998]

§97.9 Operator license grant.

(a) The classes of amateur operator license grants are: Novice, Technician, General, Advanced, and Amateur Extra. The person named in the operator license grant is authorized to be the control operator of an amateur station with the privileges authorized to the operator class specified on the license grant.

(b) The person named in an operator license grant of Novice, Technician, General or Advanced Class, who has properly submitted to the administering VEs a FCC Form 605 document requesting examination for an operator license grant of a higher class, and who holds a CSCE indicating that the person has completed the necessary examinations within the previous 365 days, is authorized to exercise the rights and privileges of the higher operator class until final disposition of the application or until 365 days following the passing of the examination, whichever comes first.

[75 FR 78169, Dec. 15, 2010]

§97.11 Stations aboard ships or aircraft.

(a) The installation and operation of an amateur station on a ship or aircraft must be approved by the master of the ship or pilot in command of the aircraft.

(b) The station must be separate from and independent of all other radio apparatus installed on the ship or aircraft, except a common antenna may be shared with a voluntary ship radio installation. The station's transmissions must not cause interference to any other apparatus installed on the ship or aircraft.

(c) The station must not constitute a hazard to the safety of life or property. For a station aboard an aircraft, the apparatus shall not be operated while the aircraft is operating under Instrument Flight Rules, as defined by the FAA, unless the station has been found to comply with all applicable FAA Rules.

§97.13 Restrictions on station location.

(a) Before placing an amateur station on land of environmental importance or that is significant in American history, architecture or culture, the licensee may be required to take certain actions prescribed by §§1.1305-1.1319 of this chapter.

(b) A station within 1600 m (1 mile) of an FCC monitoring facility must protect that facility from harmful interference. Failure to do so could result in imposition of operating restrictions upon the amateur station by a District Director pursuant to §97.121 of this part. Geographical coordinates of the facilities that require protection are listed in §0.121(c) of this chapter.

(c) Before causing or allowing an amateur station to transmit from any place where the operation of the station could cause human exposure to RF electromagnetic field levels in excess of those allowed under §1.1310 of this chapter, the licensee is required to take certain actions.

(1) The licensee must perform the routine RF environmental evaluation prescribed by §1.1307(b) of this chapter, if the power of the licensee's station exceeds the limits given in the following table:

Wavelength band	**Evaluation required if power[1] (watts) exceeds**
MF	
160 m	500
HF	
80 m	500
75 m	500
40 m	500
30 m	425
20 m	225
17 m	125
15 m	100
12 m	75
10 m	50
VHF (all bands)	50
UHF	
70 cm	70
33 cm	150
23 cm	200
13 cm	250
SHF (all bands)	250
EHF (all bands)	250
Repeater stations (all bands)	*non-building-mounted antennas:* height above ground level to lowest point of antenna <10 m *and* power >500 W ERP *building-mounted antennas:* power >500 W ERP

[1]Power = PEP input to antenna except, for repeater stations only, power exclusion is based on ERP (effective radiated power).

(2) If the routine environmental evaluation indicates that the RF electromagnetic fields could exceed the limits contained in §1.1310 of this chapter in accessible areas, the licensee must take action to prevent human exposure to such RF electromagnetic fields. Further information on evaluating compliance with these limits can be found in the FCC's OET Bulletin Number 65, “Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields.”

[54 FR 25857, June 20, 1989, as amended at 55 FR 20398, May 16, 1990; 61 FR 41019, Aug. 7, 1996; 62 FR 47963, Sept. 12, 1997; 62 FR 49557, Sept. 22, 1997; 62 FR 61448, Nov. 18, 1997; 63 FR 68978, Dec. 14, 1998; 65 FR 6549, Feb. 10, 2000]

§97.15 Station antenna structures.

(a) Owners of certain antenna structures more than 60.96 meters (200 feet) above ground level at the site or located near or at a public use airport must notify the Federal Aviation Administration and register with the Commission as required by part 17 of this chapter.

(b) Except as otherwise provided herein, a station antenna structure may be erected at heights and dimensions sufficient to accommodate amateur service communications. (State and local regulation of a station antenna structure must not preclude amateur service communications. Rather, it must reasonably accommodate such communications and must constitute the minimum practicable regulation to accomplish the state or local authority's legitimate purpose. *See* PRB-1, 101 FCC 2d 952 (1985) for details.)

[64 FR 53242, Oct. 1, 1999]

§97.17 Application for new license grant.

(a) Any qualified person is eligible to apply for a new operator/primary station, club station or military recreation station license grant. No new license grant will be issued for a Novice or Advanced Class operator/primary station.

(b) Each application for a new amateur service license grant must be filed with the FCC as follows:

(1) Each candidate for an amateur radio operator license which requires the applicant to pass one or more examination elements must present the administering VEs with all information required by the rules prior to the examination. The VEs may collect all necessary information in any manner of their choosing, including creating their own forms.

(2) For a new club or military recreation station license grant, each applicant must present all information required by the rules to an amateur radio organization having tax-exempt status under section 501(c)(3) of the Internal Revenue Code of 1986 that provides voluntary, uncompensated and unreimbursed services in providing club and military recreation station call signs ("*Club Station Call Sign Administrator*") who must submit the information to the FCC in an electronic batch file. The Club Station Call Sign Administrator may collect the information required by these rules in any manner of their choosing, including creating their own forms. The Club Station Call Sign Administrator must retain the applicants information for at least 15 months and make it available to the FCC upon request. The FCC will issue public announcements listing the qualified organizations that have completed a pilot autogrant batch filing project and are authorized to serve as a Club Station Call Sign Administrator.

(c) No person shall obtain or attempt to obtain, or assist another person to obtain or attempt to obtain, an amateur service license grant by fraudulent means.

(d) One unique call sign will be shown on the license grant of each new primary, club and military recreation station. The call sign will be selected by the sequential call sign system. Effective February 14, 2011, no club station license grants will be issued to a licensee who is shown as the license trustee on an existing club station license grant.

[63 FR 68978, Dec. 14, 1998. as amended at 64 FR 53242, Oct. 1, 1999; 65 FR 6549, Feb. 10, 2000; 75 FR 78170, Dec. 15, 2010]

§97.19 Application for a vanity call sign.

(a) The person named in an operator/primary station license grant or in a club station license grant is eligible to make application for modification of the license grant, or the renewal thereof, to show a call sign selected by the vanity call sign system. Effective February 14, 2011, the person named in a club station license grant that shows on the license a call sign that was selected by a trustee is not eligible for an additional vanity call sign. (The person named in a club station license grant that shows on the license a call sign that was selected by a trustee is eligible for a vanity call sign for his or her operator/primary station license grant on the same basis as any other person who holds an operator/primary station license grant.) Military recreation stations are not eligible for a vanity call sign.

(b) Each application for a modification of an operator/primary or club station license grant, or the renewal thereof, to show a call sign selected by the vanity call sign system must be filed in accordance with §1.913 of this chapter.

(c) Unassigned call signs are available to the vanity call sign system with the following exceptions:

(1) A call sign shown on an expired license grant is not available to the vanity call sign system for 2 years following the expiration of the license.

(2) A call sign shown on a surrendered or canceled license grant (except for a license grant that is canceled pursuant to §97.31) is not available to the vanity call sign system for 2 years following the date such action is taken. (The availability of a call sign shown on a license canceled pursuant to §97.31 is governed by paragraph (c)(3) of this section.)

(i) This 2-year period does not apply to any license grant pursuant to paragraph (c)(3)(i), (ii), or (iii) of this section that is surrendered, canceled, revoked, voided, or set aside because the grantee acknowledged or the Commission determined that the grantee was not eligible for the exception. In such a case, the call sign is not available to the vanity call sign system for 30 days following the date such action is taken, or for the period for which the call sign would not have been available to the vanity call sign system pursuant to paragraphs (c)(2) or (3) of this section but for the intervening grant to the ineligible applicant, whichever is later.

(ii) An applicant to whose operator/primary station license grant, or club station license grant for which the applicant is the trustee, the call sign was previously assigned is exempt from the 2-year period set forth in paragraph (c)(2) of this section.

(3) A call sign shown on a license canceled pursuant to §97.31 of this part is not available to the vanity call sign system for 2 years following the person's death, or for 2 years following the expiration of the license grant, whichever is sooner. If, however, a license is canceled more than 2 years after the licensee's death (or within 30 days before the second anniversary of the licensee's death), the call sign is not available to the vanity call sign system for 30 days following the date such action is taken. The following applicants are exempt from this 2-year period:

(i) An applicant to whose operator/primary station license grant, or club station license grant for which the applicant is the trustee, the call sign was previously assigned; or

(ii) An applicant who is the spouse, child, grandchild, stepchild, parent, grandparent, stepparent, brother, sister, stepbrother, stepsister, aunt, uncle, niece, nephew, or in-law of the person now deceased or of any other deceased former holder of the call sign, provided that the vanity call sign requested by the applicant is from the group of call signs corresponding to the same or lower class of operator license held by the applicant as designated in the sequential call sign system; or

(iii) An applicant who is a club station license trustee acting with a written statement of consent signed by either the licensee *ante mortem* but who is now deceased, or by at least one relative as listed in paragraph (c)(3)(ii) of this section, of the person now deceased or of any other deceased former holder of the call sign, provided that the deceased former holder was a member of the club during his or her life.

(d) The vanity call sign requested by an applicant must be selected from the group of call signs corresponding to the same or lower class of operator license held by the applicant as designated in the sequential call sign system.

(1) The applicant must request that the call sign shown on the license grant be vacated and provide a list of up to 25 call signs in order of preference. In the event that the Commission receives more than one application requesting a vanity call sign from an applicant on the same receipt day, the Commission will process only the first such application entered into the Universal Licensing System. Subsequent vanity call sign applications from that applicant with the same receipt date will not be accepted.

(2) The first assignable call sign from the applicant's list will be shown on the license grant. When none of those call signs are assignable, the call sign vacated by the applicant will be shown on the license grant.

(3) Vanity call signs will be selected from those call signs assignable at the time the application is processed by the FCC.

(4) A call sign designated under the sequential call sign system for Alaska, Hawaii, Caribbean Insular Areas, and Pacific Insular areas will be assigned only to a primary or club station whose licensee's mailing address is in the corresponding state, commonwealth, or island. This limitation does not apply to an applicant for the call sign as the spouse, child, grandchild, stepchild, parent, grandparent, stepparent, brother, sister, stepbrother, stepsister, aunt, uncle, niece, nephew, or in-law, of the former holder now deceased.

[60 FR 7460, Feb. 8, 1995, as amended at 60 FR 50123, Sept. 28, 1995; 60 FR 53132, Oct. 12, 1995; 63 FR 68979, Dec. 14, 1998; 71 FR 66461, Nov. 15, 2006; 75 FR 78170, Dec. 15, 2010]

§97.21 Application for a modified or renewed license grant.

(a) A person holding a valid amateur station license grant:

(1) Must apply to the FCC for a modification of the license grant as necessary to show the correct mailing address, licensee name, club name, license trustee name, or license custodian name in accordance with §1.913 of this chapter. For a club or military recreation station license grant, the application must be presented in document form to a Club Station Call Sign Administrator who must submit the information thereon to the FCC in an electronic batch file. The Club Station Call Sign Administrator must retain the collected information for at least 15 months and make it available to the FCC upon request. A Club Station Call Sign Administrator shall not file with the Commission any application to modify a club station license grant that was submitted by a person other than the trustee as shown on the license grant, except an application to change the club station license trustee. An application to modify a club station license grant to change the license trustee name must be submitted to a Club Station Call Sign Administrator and must be signed by an officer of the club.

(2) May apply to the FCC for a modification of the operator/primary station license grant to show a higher operator class. Applicants must present the administering VEs with all information required by the rules prior to the examination. The VEs may collect all necessary information in any manner of their choosing, including creating their own forms.

(3) May apply to the FCC for renewal of the license grant for another term in accordance with §§1.913 and 1.949 of this chapter. Application for renewal of a Technician Plus Class operator/primary station license will be processed as an application for renewal of a Technician Class operator/primary station license.

(i) For a station license grant showing a call sign obtained through the vanity call sign system, the application must be filed in accordance with §97.19 of this part in order to have the vanity call sign reassigned to the station.

(ii) For a primary station license grant showing a call sign obtained through the sequential call sign system, and for a primary station license grant showing a call sign obtained through the vanity call sign system but whose grantee does not want to have the vanity call sign reassigned to the station, the application must be filed with the FCC in accordance with §1.913 of this chapter. When the application has been received by the FCC on or before the license expiration date, the license operating authority is continued until the final disposition of the application.

(iii) For a club station or military recreation station license grant showing a call sign obtained through the sequential call sign system, and for a club station license grant showing a call sign obtained through the vanity call sign system but whose grantee does not want to have the vanity call sign reassigned to the station, the application must be presented in document form to a Club Station Call Sign Administrator who must submit the information thereon to the FCC in an electronic batch file. The replacement call sign will be selected by the sequential call sign system. The Club Station Call Sign Administrator must retain the collected information for at least 15 months and make it available to the FCC upon request.

(b) A person whose amateur station license grant has expired may apply to the FCC for renewal of the license grant for another term during a 2 year filing grace period. The application must be received at the address specified above prior to the end of the grace period. Unless and until the license grant is renewed, no privileges in this part are conferred.

(c) Except as provided in paragraph (a)(3) of this section, a call sign obtained under the sequential or vanity call sign system will be reassigned to the station upon renewal or modification of a station license.

[63 FR 68979, Dec. 14, 1998, as amended at 64 FR 53242, Oct. 1, 1999; 65 FR 6550, Feb. 10, 2000; 75 FR 78170, Dec. 15, 2010; 79 FR 35291, July 21, 2014]

§97.23 Mailing address.

Each license grant must show the grantee's correct name and mailing address. The mailing address must be in an area where the amateur service is regulated by the FCC and where the grantee can receive mail delivery by the United States Postal Service. Revocation of the station license or suspension of the operator license may result when correspondence from the FCC is returned as undeliverable because the grantee failed to provide the correct mailing address.

[63 FR 68979, Dec. 14, 1998]

§97.25 License term.

An amateur service license is normally granted for a 10-year term.

[63 FR 68979, Dec. 14, 1998]

§97.27 FCC modification of station license grant.

(a) The FCC may modify a station license grant, either for a limited time or for the duration of the term thereof, if it determines:

(1) That such action will promote the public interest, convenience, and necessity; or

(2) That such action will promote fuller compliance with the provisions of the Communications Act of 1934, as amended, or of any treaty ratified by the United States.

(b) When the FCC makes such a determination, it will issue an order of modification. The order will not become final until the licensee is notified in writing of the proposed action and the grounds and reasons therefor. The licensee will be given reasonable opportunity of no less than 30 days to protest the modification; except that, where safety of life or property is involved, a shorter period of notice may be provided. Any protest by a licensee of an FCC order of modification will be handled in accordance with the provisions of 47 U.S.C. 316.

[59 FR 54833, Nov. 2, 1994, as amended at 63 FR 68979, Dec. 14, 1998]

§97.29 Replacement license grant document.

Each grantee whose amateur station license grant document is lost, mutilated or destroyed may apply to the FCC for a replacement in accordance with §1.913 of this chapter.

[63 FR 68979, Dec. 14, 1998]

§97.31 Cancellation on account of the licensee's death.

(a) A person may request cancellation of an operator/primary station license grant on account of the licensee's death by submitting a signed request that includes a death certificate, obituary, or Social Security Death Index data that shows the person named in the operator/primary station license grant has died. Such a request may be submitted as a pleading associated with the deceased licensee's license. *See* §1.45 of this chapter. In addition, the Commission may cancel an operator/primary station license grant if it becomes aware of the grantee's death through other means. No action will be taken during the last thirty days of the post-expiration grace period (*see* §97.21(b)) on a request to cancel a license due to the licensee's death.

(b) A license that is canceled due to the licensee's death is canceled as of the date of the licensee's death.

[75 FR 78171, Dec. 15, 2010]

Subpart B—Station Operation Standards

§97.101 General standards.

(a) In all respects not specifically covered by FCC Rules each amateur station must be operated in accordance with good engineering and good amateur practice.

(b) Each station licensee and each control operator must cooperate in selecting transmitting channels and in making the most effective use of the amateur service frequencies. No frequency will be assigned for the exclusive use of any station.

(c) At all times and on all frequencies, each control operator must give priority to stations providing emergency communications, except to stations transmitting communications for training drills and tests in RACES.

(d) No amateur operator shall willfully or maliciously interfere with or cause interference to any radio communication or signal.

§97.103 Station licensee responsibilities.

(a) The station licensee is responsible for the proper operation of the station in accordance with the FCC Rules. When the control operator is a different amateur operator than the station licensee, both persons are equally responsible for proper operation of the station.

(b) The station licensee must designate the station control operator. The FCC will presume that the station licensee is also the control operator, unless documentation to the contrary is in the station records.

(c) The station licensee must make the station and the station records available for inspection upon request by an FCC representative.

[54 FR 25857, June 20, 1989, as amended at 71 FR 66462, Nov. 15, 2006; 75 FR 27201, May 14, 2010]

§97.105 Control operator duties.

(a) The control operator must ensure the immediate proper operation of the station, regardless of the type of control.

(b) A station may only be operated in the manner and to the extent permitted by the privileges authorized for the class of operator license held by the control operator.

§97.107 Reciprocal operating authority.

A non-citizen of the United States (“alien”) holding an amateur service authorization granted by the alien's government is authorized to be the control operator of an amateur station located at places where the amateur service is regulated by the FCC, provided there is in effect a multilateral or bilateral reciprocal operating arrangement, to which the United States and the alien's government are parties, for amateur service operation on a reciprocal basis. The FCC will issue public announcements listing the countries with which the United States has such an arrangement. No citizen of the United States or person holding an FCC amateur operator/primary station license grant is eligible for the reciprocal operating authority granted by this section. The privileges granted to a control operator under this authorization are:

(a) For an amateur service license granted by the Government of Canada:

(1) The terms of the *Convention Between the United States and Canada* (TIAS No. 2508) *Relating to the Operation by Citizens of Either Country of Certain Radio Equipment or Stations in the Other Country;*

(2) The operating terms and conditions of the amateur service license issued by the Government of Canada; and

(3) The applicable rules of this part, but not to exceed the control operator privileges of an FCC-granted Amateur Extra Class operator license.

(b) For an amateur service license granted by any country, other than Canada, with which the United States has a multilateral or bilateral agreement:

(1) The terms of the agreement between the alien's government and the United States;

(2) The operating terms and conditions of the amateur service license granted by the alien's government;

(3) The applicable rules of this part, but not to exceed the control operator privileges of an FCC-granted Amateur Extra Class operator license; and

(c) At any time the FCC may, in its discretion, modify, suspend or cancel the reciprocal operating authority granted to any person by this section.

[63 FR 68979, Dec. 14, 1998]

§97.109 Station control.

(a) Each amateur station must have at least one control point.

(b) When a station is being locally controlled, the control operator must be at the control point. Any station may be locally controlled.

(c) When a station is being remotely controlled, the control operator must be at the control point. Any station may be remotely controlled.

(d) When a station is being automatically controlled, the control operator need not be at the control point. Only stations specifically designated elsewhere in this part may be automatically controlled. Automatic control must cease upon notification by a District Director that the station is transmitting improperly or causing harmful interference to other stations. Automatic control must not be resumed without prior approval of the District Director.

[54 FR 39535, Sept. 27, 1989, as amended at 60 FR 26001, May 16, 1995; 69 FR 24997, May 5, 2004]

§97.111 Authorized transmissions.

(a) An amateur station may transmit the following types of two-way communications:

(1) Transmissions necessary to exchange messages with other stations in the amateur service, except those in any country whose administration has notified the ITU that it objects to such communications. The FCC will issue public notices of current arrangements for international communications.

(2) Transmissions necessary to meet essential communication needs and to facilitate relief actions.

(3) Transmissions necessary to exchange messages with a station in another FCC-regulated service while providing emergency communications;

(4) Transmissions necessary to exchange messages with a United States government station, necessary to providing communications in RACES; and

(5) Transmissions necessary to exchange messages with a station in a service not regulated by the FCC, but authorized by the FCC to communicate with amateur stations. An amateur station may exchange messages with a participating United States military station during an Armed Forces Day Communications Test.

(b) In addition to one-way transmissions specifically authorized elsewhere in this part, an amateur station may transmit the following types of one-way communications:

(1) Brief transmissions necessary to make adjustments to the station;

(2) Brief transmissions necessary to establishing two-way communications with other stations;

(3) Telecommand;

(4) Transmissions necessary to providing emergency communications;

(5) Transmissions necessary to assisting persons learning, or improving proficiency in, the international Morse code; and

(6) Transmissions necessary to disseminate information bulletins.

(7) Transmissions of telemetry.

[54 FR 25857, June 20, 1989, as amended at 56 FR 56171, Nov. 1, 1991; 71 FR 25982, May 3, 2006; 71 FR 66462, Nov. 15, 2006]

§97.113 Prohibited transmissions.

(a) No amateur station shall transmit:

(1) Communications specifically prohibited elsewhere in this part;

(2) Communications for hire or for material compensation, direct or indirect, paid or promised, except as otherwise provided in these rules;

(3) Communications in which the station licensee or control operator has a pecuniary interest, including communications on behalf of an employer, with the following exceptions:

(i) A station licensee or station control operator may participate on behalf of an employer in an emergency preparedness or disaster readiness test or drill, limited to the duration and scope of such test or drill, and operational testing immediately prior to such test or drill. Tests or drills that are not government-sponsored are limited to a total time of one hour per week; except that no more than twice in any calendar year, they may be conducted for a period not to exceed 72 hours.

(ii) An amateur operator may notify other amateur operators of the availability for sale or trade of apparatus normally used in an amateur station, provided that such activity is not conducted on a regular basis.

(iii) A control operator may accept compensation as an incident of a teaching position during periods of time when an amateur station is used by that teacher as a part of classroom instruction at an educational institution.

(iv) The control operator of a club station may accept compensation for the periods of time when the station is transmitting telegraphy practice or information bulletins, provided that the station transmits such telegraphy practice and bulletins for at least 40 hours per week; schedules operations on at least six amateur service MF and HF bands using reasonable measures to maximize coverage; where the schedule of normal operating times and frequencies is published at least 30 days in advance of the actual transmissions; and where the control operator does not accept any direct or indirect compensation for any other service as a control operator.

(4) Music using a phone emission except as specifically provided elsewhere in this section; communications intended to facilitate a criminal act; messages encoded for the purpose of obscuring their meaning, except as otherwise provided herein; obscene or indecent words or language; or false or deceptive messages, signals or identification.

(5) Communications, on a regular basis, which could reasonably be furnished alternatively through other radio services.

(b) An amateur station shall not engage in any form of broadcasting, nor may an amateur station transmit one-way communications except as specifically provided in these rules; nor shall an amateur station engage in any activity related to program production or news gathering for broadcasting purposes, except that communications directly related to the immediate safety of human life or the protection of property may be provided by amateur stations to broadcasters for dissemination to the public where no other means of communication is reasonably available before or at the time of the event.

(c) No station shall retransmit programs or signals emanating from any type of radio station other than an amateur station, except propagation and weather forecast information intended for use by the general public and originated from United States Government stations, and communications, including incidental music, originating on United States Government frequencies between a manned spacecraft and its associated Earth stations. Prior approval for manned spacecraft communications retransmissions must be obtained from the National Aeronautics and Space Administration. Such retransmissions must be for the exclusive use of amateur radio operators. Propagation, weather forecasts, and manned spacecraft communications retransmissions may not be conducted on a regular basis, but only occasionally, as an incident of normal amateur radio communications.

(d) No amateur station, except an auxiliary, repeater, or space station, may automatically retransmit the radio signals of other amateur station.

[58 FR 43072, Aug. 13, 1993; 58 FR 47219, Sept. 8, 1993, as amended at 71 FR 25982, May 3, 2006; 71 FR 66462, Nov. 15, 2006; 75 FR 46857, Aug. 4, 2010; 79 FR 35291, June 20, 2014]

§97.115 Third party communications.

(a) An amateur station may transmit messages for a third party to:

(1) Any station within the jurisdiction of the United States.

(2) Any station within the jurisdiction of any foreign government when transmitting emergency or disaster relief communications and any station within the jurisdiction of any foreign government whose administration has made arrangements with the United States to allow amateur stations to be used for transmitting international communications on behalf of third parties. No station shall transmit messages for a third party to any station within the jurisdiction of any foreign government whose administration has not made such an arrangement. This prohibition does not apply to a message for any third party who is eligible to be a control operator of the station.

(b) The third party may participate in stating the message where:

(1) The control operator is present at the control point and is continuously monitoring and supervising the third party's participation; and

(2) The third party is not a prior amateur service licensee whose license was revoked or not renewed after hearing and re-licensing has not taken place; suspended for less than the balance of the license term and the suspension is still in effect; suspended for the balance of the license term and re-licensing has not taken place; or surrendered for cancellation following notice of revocation, suspension or monetary forfeiture proceedings. The third party may not be the subject of a cease and desist order which relates to amateur service operation and which is still in effect.

(c) No station may transmit third party communications while being automatically controlled except a station transmitting a RTTY or data emission.

(d) At the end of an exchange of international third party communications, the station must also transmit in the station identification procedure the call sign of the station with which a third party message was exchanged.

[54 FR 25857, June 20, 1989; 54 FR 39535, Sept. 27, 1989, as amended at 71 FR 25982, May 3, 2006; 71 FR 66462, Nov. 15, 2006]

§97.117 International communications.

Transmissions to a different country, where permitted, shall be limited to communications incidental to the purposes of the amateur service and to remarks of a personal character.

[71 FR 25982, May 3, 2006]

§97.119 Station identification.

(a) Each amateur station, except a space station or telecommand station, must transmit its assigned call sign on its transmitting channel at the end of each communication, and at least every 10 minutes during a communication, for the purpose of clearly making the source of the transmissions from the station known to those receiving the transmissions. No station may transmit unidentified communications or signals, or transmit as the station call sign, any call sign not authorized to the station.

(b) The call sign must be transmitted with an emission authorized for the transmitting channel in one of the following ways:

(1) By a CW emission. When keyed by an automatic device used only for identification, the speed must not exceed 20 words per minute;

(2) By a phone emission in the English language. Use of a phonetic alphabet as an aid for correct station identification is encouraged;

(3) By a RTTY emission using a specified digital code when all or part of the communications are transmitted by a RTTY or data emission;

(4) By an image emission conforming to the applicable transmission standards, either color or monochrome, of §73.682(a) of the FCC Rules when all or part of the communications are transmitted in the same image emission

(c) One or more indicators may be included with the call sign. Each indicator must be separated from the call sign by the slant mark (/) or by any suitable word that denotes the slant mark. If an indicator is self-assigned, it must be included before, after, or both before and after, the call sign. No self-assigned indicator may conflict with any other indicator specified by the FCC Rules or with any prefix assigned to another country.

(d) When transmitting in conjunction with an event of special significance, a station may substitute for its assigned call sign a special event call sign as shown for that station for that period of time on the common data base coordinated, maintained and disseminated by the special event call sign data base coordinators. Additionally, the station must transmit its assigned call sign at least once per hour during such transmissions.

(e) When the operator license class held by the control operator exceeds that of the station licensee, an indicator consisting of the call sign assigned to the control operator's station must be included after the call sign.

(f) When the control operator is a person who is exercising the rights and privileges authorized by §97.9(b) of this part, an indicator must be included after the call sign as follows:

(1) For a control operator who has requested a license modification from Novice Class to Technical Class: KT;

(2) For a control operator who has requested a license modification from Novice or Technician to General Class: AG;

(3) For a control operator who has requested a license modification from Novice, Technician, General, or Advanced Class to Amateur Extra Class: AE.

(g) When the station is transmitting under the authority of §97.107 of this part, an indicator consisting of the appropriate letter-numeral designating the station location must be included before the call sign that was issued to the station by the country granting the license. For an amateur service license granted by the Government of Canada, however, the indicator must be included after the call sign. At least once during each intercommunication, the identification announcement must include the geographical location as nearly as possible by city and state, commonwealth or possession.

[54 FR 25857, June 20, 1989, as amended at 54 FR 39535, Sept. 27, 1989; 55 FR 30457, July 26, 1990; 56 FR 28, Jan. 2, 1991; 62 FR 17567, Apr. 10, 1997; 63 FR 68980, Dec. 14, 1998; 64 FR 51471, Sept. 23, 1999; 66 FR 20752, Apr. 25, 2001; 75 FR 78171, Dec. 15, 2010]

§97.121 Restricted operation.

(a) If the operation of an amateur station causes general interference to the reception of transmissions from stations operating in the domestic broadcast service when receivers of good engineering design, including adequate selectivity characteristics, are used to receive such transmissions, and this fact is made known to the amateur station licensee, the amateur station shall not be operated during the hours from 8 p.m. to 10:30 p.m., local time, and on Sunday for the additional period from 10:30 a.m. until 1 p.m., local time, upon the frequency or frequencies used when the interference is created.

(b) In general, such steps as may be necessary to minimize interference to stations operating in other services may be required after investigation by the FCC.

Subpart C—Special Operations

§97.201 Auxiliary station.

(a) Any amateur station licensed to a holder of a Technician, General, Advanced or Amateur Extra Class operator license may be an auxiliary station. A holder of a Technician, General, Advanced or Amateur Extra Class operator license may be the control operator of an auxiliary station, subject to the privileges of the class of operator license held.

(b) An auxiliary station may transmit only on the 2 m and shorter wavelength bands, except the 144.0-144.5 MHz, 145.8-146.0 MHz, 219-220 MHz, 222.00-222.15 MHz, 431-433 MHz, and 435-438 MHz segments.

(c) Where an auxiliary station causes harmful interference to another auxiliary station, the licensees are equally and fully responsible for resolving the interference unless one station's operation is recommended by a frequency coordinator and the other station's is not. In that case, the licensee of the non-coordinated auxiliary station has primary responsibilty to resolve the interference.

(d) An auxiliary station may be automatically controlled.

(e) An auxiliary station may transmit one-way communications.

[54 FR 25857, June 20, 1989, as amended at 56 FR 56171, Nov. 1, 1991; 60 FR 15687, Mar. 27, 1995; 63 FR 68980, Dec. 14, 1998; 71 FR 66462, Nov. 15, 2006; 75 FR 78171, Dec. 15, 2010]

§97.203 Beacon station.

(a) Any amateur station licensed to a holder of a Technician, General, Advanced or Amateur Extra Class operator license may be a beacon. A holder of a Technician, General, Advanced or Amateur Extra Class operator license may be the control operator of a beacon, subject to the privileges of the class of operator license held.

(b) A beacon must not concurrently transmit on more than 1 channel in the same amateur service frequency band, from the same station location.

(c) The transmitter power of a beacon must not exceed 100 W.

(d) A beacon may be automatically controlled while it is transmitting on the 28.20-28.30 MHz, 50.06-50.08 MHz, 144.275-144.300 MHz, 222.05-222.06 MHz or 432.300-432.400 MHz segments, or on the 33 cm and shorter wavelength bands.

(e) Before establishing an automatically controlled beacon in the National Radio Quiet Zone or before changing the transmitting frequency, transmitter power, antenna height or directivity, the station licensee must give written notification thereof to the Interference Office, National Radio Astronomy Observatory, P.O. Box 2, Green Bank, WV 24944.

(1) The notification must include the geographical coordinates of the antenna, antenna ground elevation above mean sea level (AMSL), antenna center of radiation above ground level (AGL), antenna directivity, proposed frequency, type of emission, and transmitter power.

(2) If an objection to the proposed operation is received by the FCC from the National Radio Astronomy Observatory at Green Bank, Pocahontas County, WV, for itself or on behalf of the Naval Research Laboratory at Sugar Grove, Pendleton County, WV, within 20 days from the date of notification, the FCC will consider all aspects of the problem and take whatever action is deemed appropriate.

(f) A beacon must cease transmissions upon notification by a District Director that the station is operating improperly or causing undue interference to other operations. The beacon may not resume transmitting without prior approval of the District Director.

(g) A beacon may transmit one-way communications.

[54 FR 25857, June 20, 1989, as amended at 55 FR 9323, Mar. 13, 1990; 56 FR 19610, Apr. 29, 1991; 56 FR 32517, July 17, 1991; 62 FR 55536, Oct. 27, 1997; 63 FR 41204, Aug. 3, 1998; 63 FR 68980, Dec. 14, 1998; 69 FR 24997, May 5, 2004; 71 FR 66462, Nov. 15, 2006; 75 FR 78171, Dec. 15, 2010]

§97.205 Repeater station.

(a) Any amateur station licensed to a holder of a Technician, General, Advanced or Amateur Extra Class operator license may be a repeater. A holder of a Technician, General, Advanced or Amateur Extra Class operator license may be the control operator of a repeater, subject to the privileges of the class of operator license held.

(b) A repeater may receive and retransmit only on the 10 m and shorter wavelength frequency bands except the 28.0-29.5 MHz, 50.0-51.0 MHz, 144.0-144.5 MHz, 145.5-146.0 MHz, 222.00-222.15 MHz, 431.0-433.0 Mhz, and 435.0-438.0 Mhz segments.

(c) Where the transmissions of a repeater cause harmful interference to another repeater, the two station licensees are equally and fully responsible for resolving the interference unless the operation of one station is recommended by a frequency coordinator and the operation of the other station is not. In that case, the licensee of the non-coordinated repeater has primary responsibility to resolve the interference.

(d) A repeater may be automatically controlled.

(e) Ancillary functions of a repeater that are available to users on the input channel are not considered remotely controlled functions of the station. Limiting the use of a repeater to only certain user stations is permissible.

(f) [Reserved]

(g) The control operator of a repeater that retransmits inadvertently communications that violate the rules in this part is not accountable for the violative communications.

(h) The provisions of this paragraph do not apply to repeaters that transmit on the 1.2 cm or shorter wavelength bands. Before establishing a repeater within 16 km (10 miles) of the Arecibo Observatory or before changing the transmitting frequency, transmitter power, antenna height or directivity of an existing repeater, the station licensee must give written notification thereof to the Interference Office, Arecibo Observatory, HC3 Box 53995, Arecibo, Puerto Rico 00612, in writing or electronically, of the technical parameters of the proposal. Licensees who choose to transmit information electronically should e-mail to: *prcz@naic.edu.*

(1) The notification shall state the geographical coordinates of the antenna (NAD-83 datum), antenna height above mean sea level (AMSL), antenna center of radiation above ground level (AGL), antenna directivity and gain, proposed frequency and FCC Rule Part, type of emission, effective radiated power, and whether the proposed use is itinerant. Licensees may wish to consult interference guidelines provided by Cornell University.

(2) If an objection to the proposed operation is received by the FCC from the Arecibo Observatory, Arecibo, Puerto Rico, within 20 days from the date of notification, the FCC will consider all aspects of the problem and take whatever action is deemed appropriate. The licensee will be required to make reasonable efforts in order to resolve or mitigate any potential interference problem with the Arecibo Observatory.

[54 FR 25857, June 20, 1989, as amended at 55 FR 4613, Feb. 9, 1990; 56 FR 32517, July 17, 1991; 58 FR 64385, Dec. 7, 1993; 59 FR 18975, Apr. 21, 1994; 62 FR 55536, Oct. 27, 1997; 63 FR 41205, Aug. 3, 1998; 63 FR 68980, Dec. 14, 1998; 69 FR 24997, May 5, 2004; 70 FR 31374, June 1, 2005]

§97.207 Space station.

(a) Any amateur station may be a space station. A holder of any class operator license may be the control operator of a space station, subject to the privileges of the class of operator license held by the control operator.

(b) A space station must be capable of effecting a cessation of transmissions by telecommand whenever such cessation is ordered by the FCC.

(c) The following frequency bands and segments are authorized to space stations:

(1) The 17 m, 15 m, 12 m, and 10 m bands, 6 mm, 4 mm, 2 mm and 1 mm bands; and

(2) The 7.0-7.1 MHz, 14.00-14.25 MHz, 144-146 MHz, 435-438 MHz, 2400-2450 MHz, 3.40-3.41 GHz, 5.83-5.85 GHz, 10.45-10.50 GHz, and 24.00-24.05 GHz segments.

(d) A space station may automatically retransmit the radio signals of Earth stations and other space stations.

(e) A space station may transmit one-way communications.

(f) Space telemetry transmissions may consist of specially coded messages intended to facilitate communications or related to the function of the spacecraft.

(g) The license grantee of each space station must make the following written notifications to the International Bureau, FCC, Washington, DC 20554.

(1) A pre-space notification within 30 days after the date of launch vehicle determination, but no later than 90 days before integration of the space station into the launch vehicle. The notification must be in accordance with the provisions of Articles 9 and 11 of the International Telecommunication Union (ITU) Radio Regulations and must specify the information required by Appendix 4 and Resolution No. 642 of the ITU Radio Regulations. The notification must also include a description of the design and operational strategies that the space station will use to mitigate orbital debris, including the following information:

(i) A statement that the space station licensee has assessed and limited the amount of debris released in a planned manner during normal operations, and has assessed and limited the probability of the space station becoming a source of debris by collisions with small debris or meteoroids that could cause loss of control and prevent post-mission disposal;

(ii) A statement that the space station licensee has assessed and limited the probability of accidental explosions during and after completion of mission operations. This statement must include a demonstration that debris generation will not result from the conversion of energy sources on board the spacecraft into energy that fragments the spacecraft. Energy sources include chemical, pressure, and kinetic energy. This demonstration should address whether stored energy will be removed at the spacecraft's end of life, by depleting residual fuel and leaving all fuel line valves open, venting any pressurized system, leaving all batteries in a permanent discharge state, and removing any remaining source of stored energy, or through other equivalent procedures specifically disclosed in the application;

(iii) A statement that the space station licensee has assessed and limited the probability of the space station becoming a source of debris by collisions with large debris or other operational space stations. Where a space station will be launched into a low-Earth orbit that is identical, or very similar, to an orbit used by other space stations, the statement must include an analysis of the potential risk of collision and a description of what measures the space station operator plans to take to avoid in-orbit collisions. If the space station licensee is relying on coordination with another system, the statement must indicate what steps have been taken to contact, and ascertain the likelihood of successful coordination of physical operations with, the other system. The statement must disclose the accuracy—if any—with which orbital parameters of non-geostationary satellite orbit space stations will be maintained, including apogee, perigee, inclination, and the right ascension of the ascending node(s). In the event that a system is not able to maintain orbital tolerances, *i.e.*, it lacks a propulsion system for orbital maintenance, that fact should be included in the debris mitigation disclosure. Such systems must also indicate the anticipated evolution over time of the orbit of the proposed satellite or satellites. Where a space station requests the assignment of a geostationary-Earth orbit location, it must assess whether there are any known satellites located at, or reasonably expected to be located at, the requested orbital location, or assigned in the vicinity of that location, such that the station keeping volumes of the respective satellites might overlap. If so, the statement must include a statement as to the identities of those parties and the measures that will be taken to prevent collisions;

(iv) A statement detailing the post-mission disposal plans for the space station at end of life, including the quantity of fuel—if any—that will be reserved for post-mission disposal maneuvers. For geostationary-Earth orbit space stations, the statement must disclose the altitude selected for a post-mission disposal orbit and the calculations that are used in deriving the disposal altitude. The statement must also include a casualty risk assessment if planned post-mission disposal involves atmospheric re-entry of the space station. In general, an assessment should include an estimate as to whether portions of the spacecraft will survive re-entry and reach the surface of the Earth, as well as an estimate of the resulting probability of human casualty.

(v) If any material item described in this notification changes before launch, a replacement pre-space notification shall be filed with the International Bureau no later than 90 days before integration of the space station into the launch vehicle.

(2) An in-space station notification is required no later than 7 days following initiation of space station transmissions. This notification must update the information contained in the pre-space notification.

(3) A post-space station notification is required no later than 3 months after termination of the space station transmissions. When termination of transmissions is ordered by the FCC, the notification is required no later than 24 hours after termination of transmissions.

[54 FR 25857, June 20, 1989, as amended at 54 FR 39535, Sept. 27, 1989; 56 FR 56171, Nov. 1, 1991; 57 FR 32736, July 23, 1992; 60 FR 50124, Sept. 28, 1995; 63 FR 68980, Dec. 14, 1998; 69 FR 54588, Sept. 9, 2004; 71 FR 66462, Nov. 15, 2006; 75 FR 27201, May 14, 2010]

§97.209 Earth station.

(a) Any amateur station may be an Earth station. A holder of any class operator license may be the control operator of an Earth station, subject to the privileges of the class of operator license held by the control operator.

(b) The following frequency bands and segments are authorized to Earth stations:

(1) The 17 m, 15 m, 12 m, and 10 m bands, 6 mm, 4 mm, 2 mm and 1 mm bands; and

(2) The 7.0-7.1 MHz, 14.00-14.25 MHz, 144-146 MHz, 435-438 MHz, 1260-1270 MHz and 2400-2450 MHz, 3.40-3.41 GHz, 5.65-5.67 GHz, 10.45-10.50 GHz and 24.00-24.05 GHz segments.

[54 FR 25857, June 20, 1989, as amended at 54 FR 39535, Sept. 27, 1989]

§97.211 Space telecommand station.

(a) Any amateur station designated by the licensee of a space station is eligible to transmit as a telecommand station for that space station, subject to the privileges of the class of operator license held by the control operator.

(b) A telecommand station may transmit special codes intended to obscure the meaning of telecommand messages to the station in space operation.

(c) The following frequency bands and segments are authorized to telecommand stations:

(1) The 17 m, 15 m, 12 m and 10 m bands, 6 mm, 4 mm, 2 mm and 1 mm bands; and

(2) The 7.0-7.1 MHz, 14.00-14.25 MHz, 144-146 MHz, 435-438 MHz, 1260-1270 MHz and 2400-2450 MHz, 3.40-3.41 GHz, 5.65-5.67 GHz, 10.45-10.50 GHz and 24.00-24.05 GHz segments.

(d) A telecommand station may transmit one-way communications.

[54 FR 25857, June 20, 1989, as amended at 54 FR 39535, Sept. 27, 1989; 56 FR 56171, Nov. 1, 1991]

§97.213 Telecommand of an amateur station.

An amateur station on or within 50 km of the Earth's surface may be under telecommand where:

(a) There is a radio or wireline control link between the control point and the station sufficient for the control operator to perform his/her duties. If radio, the control link must use an auxiliary station. A control link using a fiber optic cable or another telecommunication service is considered wireline.

(b) Provisions are incorporated to limit transmission by the station to a period of no more than 3 minutes in the event of malfunction in the control link.

(c) The station is protected against making, willfully or negligently, unauthorized transmissions.

(d) A photocopy of the station license and a label with the name, address, and telephone number of the station licensee and at least one designated control operator is posted in a conspicuous place at the station location.

[54 FR 25857, June 20, 1989, as amended at 56 FR 56171, Nov. 1, 1991]

§97.215 Telecommand of model craft.

An amateur station transmitting signals to control a model craft may be operated as follows:

(a) The station identification procedure is not required for transmissions directed only to the model craft, provided that a label indicating the station call sign and the station licensee's name and address is affixed to the station transmitter.

(b) The control signals are not considered codes or ciphers intended to obscure the meaning of the communication.

(c) The transmitter power must not exceed 1 W.

[54 FR 25857, June 20, 1989, as amended at 56 FR 56171, Nov. 1, 1991]

§97.217 Telemetry.

Telemetry transmitted by an amateur station on or within 50 km of the Earth's surface is not considered to be codes or ciphers intended to obscure the meaning of communications.

[56 FR 56172, Nov. 1, 1991. Redesignated at 59 FR 18975, Apr. 21, 1994]

§97.219 Message forwarding system.

(a) Any amateur station may participate in a message forwarding system, subject to the privileges of the class of operator license held.

(b) For stations participating in a message forwarding system, the control operator of the station originating a message is primarily accountable for any violation of the rules in this part contained in the message.

(c) Except as noted in (d) of this section, for stations participating in a message forwarding system, the control operators of forwarding stations that retransmit inadvertently communications that violate the rules in this part are not accountable for the violative communications. They are, however, responsible for discontinuing such communications once they become aware of their presence.

(d) For stations participating in a message forwarding system, the control operator of the first forwarding station must:

(1) Authenticate the identity of the station from which it accepts communications on behalf of the system; or

(2) Accept accountability for any violation of the rules in this part contained in messages it retransmits to the system.

[59 FR 18975, Apr. 21, 1994]

§97.221 Automatically controlled digital station.

(a) This rule section does not apply to an auxiliary station, a beacon station, a repeater station, an earth station, a space station, or a space telecommand station.

(b) A station may be automatically controlled while transmitting a RTTY or data emission on the 6 m or shorter wavelength bands, and on the 28.120-28.189 MHz, 24.925-24.930 MHz, 21.090-21.100 MHz, 18.105-18.110 MHz, 14.0950-14.0995 MHz, 14.1005-14.112 MHz, 10.140-10.150 MHz, 7.100-7.105 MHz, or 3.585-3.600 MHz segments.

(c) Except for channels specified in §97.303(h), a station may be automatically controlled while transmitting a RTTY or data emission on any other frequency authorized for such emission types provided that:

(1) The station is responding to interrogation by a station under local or remote control; and

(2) No transmission from the automatically controlled station occupies a bandwidth of more than 500 Hz.

[60 FR 26001, May 16, 1995, as amended at 72 FR 3082, Jan. 24, 2007; 77 FR 5412, Feb. 3, 2012]

Subpart D—Technical Standards

§97.301 Authorized frequency bands.

The following transmitting frequency bands are available to an amateur station located within 50 km of the Earth's surface, within the specified ITU Region, and outside any area where the amateur service is regulated by any authority other than the FCC.

(a) For a station having a control operator who has been granted a Technician, General, Advanced, or Amateur Extra Class operator license or who holds a CEPT radio-amateur license or IARP of any class:

Wavelength band	**ITU region 1**	**ITU region 2**	**ITU region 3**	**Sharing requirements *see* §97.303 (paragraph)**
VHF	**MHz**	**MHz**	**MHz**	
6 m		50-54	50-54	(a)
2 m	144-146	144-148	144-148	(a), (k)
1.25 m		219-220		(l)
Do		222-225		(a)
UHF	**MHz**	**MHz**	**MHz**	
70 cm	430-440	420-450	430-440	(a), (b), (m)
33 cm		902-928		(a), (b), (e), (n)
23 cm	1240-1300	1240-1300	1240-1300	(b), (d), (o)
13 cm	2300-2310	2300-2310	2300-2310	(d), (p)
Do	2390-2450	2390-2450	2390-2450	(d), (e), (p)
SHF	**GHz**	**GHz**	**GHz**	
9 cm		3.3-3.5	3.3-3.5	(a), (b), (f), (q)
5 cm	5.650-5.850	5.650-5.925	5.650-5.850	(a), (b), (e), (r)
3 cm	10.0-10.5	10.0-10.5	10.0-10.5	(a), (b), (k)
1.2 cm	24.00-24.25	24.00-24.25	24.00-24.25	(b), (d), (e)
EHF	**GHz**	**GHz**	**GHz**	
6 mm	47.0-47.2	47.0-47.2	47.0-47.2	
4 mm	76-81	76-81	76-81	(c), (f), (s)
2.5 mm	122.25-123.00	122.25-123.00	122.25-123.00	(e), (t)
2 mm	134-141	134-141	134-141	(c), (f)
1 mm	241-250	241-250	241-250	(c), (e), (f)
	Above 275	Above 275	Above 275	(f)

(b) For a station having a control operator who has been granted an Amateur Extra Class operator license, who holds a CEPT radio amateur license, or who holds a Class 1 IARP license:

Wavelength band	**ITU region 1**	**ITU region 2**	**ITU region 3**	**Sharing requirements *see* §97.303 (paragraph)**
MF	**kHz**	**kHz**	**kHz**	
160 m	1810-1850	1800-2000	1800-2000	(a), (c), (g)
HF	**MHz**	**MHz**	**MHz**	
80 m	3.500-3.600	3.500-3.600	3.500-3.600	(a)

75 m	3.600-3.800	3.600-4.000	3.600-3.900	(a)
60 m		See §97.303(h)		(h)
40 m	7.000-7.200	7.000-7.300	7.000-7.200	(i)
30 m	10.100-10.150	10.100-10.150	10.100-10.150	(j)
20 m	14.000-14.350	14.000-14.350	14.000-14.350	
17 m	18.068-18.168	18.068-18.168	18.068-18.168	
15 m	21.000-21.450	21.000-21.450	21.000-21.450	
12 m	24.890-24.990	24.890-24.990	24.890-24.990	
10 m	28.000-29.700	28.000-29.700	28.000-29.700	

(c) For a station having a control operator who has been granted an operator license of Advanced Class:

Wavelength band	**ITU region 1**	**ITU region 2**	**ITU region 3**	**Sharing requirements *see* §97.303 (Paragraph)**
MF	**kHz**	**kHz**	**kHz**	
160 m	1810-1850	1800-2000	1800-2000	(a), (c), (g)
HF	**MHz**	**MHz**	**MHz**	
80 m	3.525-3.600	3.525-3.600	3.525-3.600	(a)
75 m	3.700-3.800	3.700-4.000	3.700-3.900	(a)
60 m		See §97.303(h)		(h)
40 m	7.025-7.200	7.025-7.300	7.025-7.200	(i)
30 m	10.100-10.150	10.100-10.150	10.100-10.150	(j)
20 m	14.025-14.150	14.025-14.150	14.025-14.150	
Do	14.175-14.350	14.175-14.350	14.175-14.350	
17 m	18.068-18.168	18.068-18.168	18.068-18.168	
15 m	21.025-21.200	21.025-21.200	21.025-21.200	
Do	21.225-21.450	21.225-21.450	21.225-21.450	
12 m	24.890-24.990	24.890-24.990	24.890-24.990	
10 m	28.000-29.700	28.000-29.700	28.000-29.700	

(d) For a station having a control operator who has been granted an operator license of General Class:

Wavelength band	**ITU region 1**	**ITU region 2**	**ITU region 3**	**Sharing requirements *see* §97.303 (paragraph)**
MF	**kHz**	**kHz**	**kHz**	
160 m	1810-1850	1800-2000	1800-2000	(a), (c), (g)
HF	**MHz**	**MHz**	**MHz**	
80 m	3.525-3.600	3.525-3.600	3.525-3.600	(a)
75 m		3.800-4.000	3.800-3.900	(a)
60 m		See §97.303(h)		(h)
40 m	7.025-7.125	7.025-7.125	7.025-7.125	(i)
Do	7.175-7.200	7.175-7.300	7.175-7.200	(i)
30 m	10.100-10.150	10.100-10.150	10.100-10.150	(j)
20 m	14.025-14.150	14.025-14.150	14.025-14.150	
Do	14.225-14.350	14.225-14.350	14.225-14.350	
17 m	18.068-18.168	18.068-18.168	18.068-18.168	
15 m	21.025-21.200	21.025-21.200	21.025-21.200	

Do	21.275-21.450	21.275-21.450	21.275-21.450	
12 m	24.890-24.990	24.890-24.990	24.890-24.990	
10 m	28.000-29.700	28.000-29.700	28.000-29.700	

(e) For a station having a control operator who has been granted an operator license of Novice Class or Technician Class:

Wavelength band	**ITU region 1**	**ITU region 2**	**ITU region 3**	**Sharing requirements *see* §97.303 (paragraph)**
HF	**MHz**	**MHz**	**MHz**	
80 m	3.525-3.600	3.525-3.600	3.525-3.600	(a)
40 m	7.025-7.125	7.025-7.125	7.025-7.125	(i)
15 m	21.025-21.200	21.025-21.200	21.025-21.200	
10 m	28.0-28.5	28.0-28.5	28.0-28.5	
VHF	**MHz**	**MHz**	**MHz**	
1.25 m		222-225		(a)
UHF	**MHz**	**MHz**	**MHz**	
23 cm	1270-1295	1270-1295	1270-1295	(d), (o)

[75 FR 27201, May 14, 2010, as amended at 75 FR 78171, Dec. 15, 2010]

§97.303 Frequency sharing requirements.

The following paragraphs summarize the frequency sharing requirements that apply to amateur stations transmitting in the frequency bands specified in §97.301 of this part. Each frequency band allocated to the amateur service is designated as either a secondary service or a primary service. A station in a secondary service must not cause harmful interference to, and must accept interference from, stations in a primary service.

(a) Where, in adjacent ITU Regions or sub-Regions, a band of frequencies is allocated to different services of the same category (*i.e.,* primary or secondary services), the basic principle is the equality of right to operate. Accordingly, stations of each service in one Region or sub-Region must operate so as not to cause harmful interference to any service of the same or higher category in the other Regions or sub-Regions.

(b) Amateur stations transmitting in the 70 cm band, the 33 cm band, the 23 cm band, the 9 cm band, the 5 cm band, the 3 cm band, or the 24.05-24.25 GHz segment must not cause harmful interference to, and must accept interference from, stations authorized by the United States Government in the radiolocation service.

(c) Amateur stations transmitting in the 1900-2000 kHz segment, the 76-77.5 GHz segment, the 78-81 GHz segment, the 136-141 GHz segment, or the 241-248 GHz segment must not cause harmful interference to, and must accept interference from, stations authorized by the United States Government, the FCC, or other nations in the radiolocation service.

(d) Amateur stations transmitting in the 430-450 MHz segment, the 23 cm band, the 3.3-3.4 GHz segment, the 5.65-5.85 GHz segment, the 13 cm band, or the 24.05-24.25 GHz segment, must not cause harmful interference to, and must accept interference from, stations authorized by other nations in the radiolocation service.

(e) Amateur stations receiving in the 33 cm band, the 2400-2450 MHz segment, the 5.725-5.875 GHz segment, the 1.2 cm band, the 2.5 mm band, or the 244-246 GHz segment must accept interference from industrial, scientific, and medical (ISM) equipment.

(f) Amateur stations transmitting in the following segments must not cause harmful interference to radio astronomy stations: 3.332-3.339 GHz, 3.3458-3.3525 GHz, 76-77.5 GHz, 78-81 GHz, 136-141 GHz, 241-248 GHz, 275-323 GHz, 327-371 GHz, 388-424 GHz, 426-442 GHz, 453-510 GHz, 623-711 GHz, 795-909 GHz, or 926-945 GHz. In addition, amateur stations transmitting in the following segments must not cause harmful interference to stations in the Earth exploration-satellite service (passive) or the space research service (passive): 275-277 GHz, 294-306 GHz, 316-334 GHz, 342-349 GHz, 363-365 GHz, 371-389 GHz, 416-434 GHz, 442-444 GHz, 496-506 GHz, 546-568 GHz, 624-629 GHz, 634-654 GHz, 659-661 GHz, 684-692 GHz, 730-732 GHz, 851-853 GHz, or 951-956 GHz.

(g) Amateur stations transmitting in the 1900-2000 kHz segment must not cause harmful interference to, and must accept interference from, stations authorized by other nations in the fixed, mobile except aeronautical mobile, and radionavigation services.

(h) *60 m band:* (1) In the 5330.5-5406.4 kHz band (60 m band), amateur stations may transmit only on the five center frequencies specified in the table below. In order to meet this requirement, control operators of stations transmitting phone, data, and RTTY emissions (emission designators 2K80J3E, 2K80J2D, and 60H0J2B, respectively) may set the carrier frequency 1.5 kHz below the center frequency as specified in the table below. For CW emissions (emission designator 150HA1A), the carrier frequency is set to the center frequency. Amateur operators shall ensure that their emissions do not occupy more than 2.8 kHz centered on each of these center frequencies.

0 M BAND FREQUENCIES (KHZ)

Carrier	Center
5330.5	5332.0
5346.5	5348.0
5357.0	5358.5
5371.5	5373.0
5403.5	5405.0

(2) Amateur stations transmitting on the 60 m band must not cause harmful interference to, and must accept interference from, stations authorized by:

(i) The United States (NTIA and FCC) and other nations in the fixed service; and

(ii) Other nations in the mobile except aeronautical mobile service.

(i) Amateur stations transmitting in the 7.2-7.3 MHz segment must not cause harmful interference to, and must accept interference from, international broadcast stations whose programming is intended for use within Region 1 or Region 3.

(j) Amateur stations transmitting in the 30 m band must not cause harmful interference to, and must accept interference from, stations by other nations in the fixed service. The licensee of the amateur station must make all necessary adjustments, including termination of transmissions, if harmful interference is caused.

(k) For amateur stations located in ITU Regions 1 and 3: Amateur stations transmitting in the 146-148 MHz segment or the 10.00-10.45 GHz segment must not cause harmful interference to, and must accept interference from, stations of other nations in the fixed and mobile services.

(l) *In the 219-220 MHz segment:*

(1) Use is restricted to amateur stations participating as forwarding stations in fixed point-to-point digital message forwarding systems, including intercity packet backbone networks. It is not available for other purposes.

(2) Amateur stations must not cause harmful interference to, and must accept interference from, stations authorized by:

(i) The FCC in the Automated Maritime Telecommunications System (AMTS), the 218-219 MHz Service, and the 220 MHz Service, and television stations broadcasting on channels 11 and 13; and

(ii) Other nations in the fixed and maritime mobile services.

(3) No amateur station may transmit unless the licensee has given written notification of the station's specific geographic location for such transmissions in order to be incorporated into a database that has been made available to the public. The notification must be given at least 30 days prior to making such transmissions. The notification must be given to: The American Radio Relay League, Inc., 225 Main Street, Newington, CT 06111-1494.

(4) No amateur station may transmit from a location that is within 640 km of an AMTS coast station that operates in the 217-218 MHz and 219-220 MHz bands unless the amateur station licensee has given written notification of the station's specific geographic location for such transmissions to the AMTS licensee. The notification must be given at least 30 days prior to making such transmissions. The location of AMTS coast stations using the 217-218/219-220 MHz channels may be obtained as noted in paragraph (l)(3) of this section.

(5) No amateur station may transmit from a location that is within 80 km of an AMTS coast station that uses frequencies in the 217-218 MHz and 219-220 MHz bands unless that amateur station licensee holds written approval from that AMTS licensee. The location of AMTS coast stations using the 217-218/219-220 MHz channels may be obtained as noted in paragraph (l)(3) of this section.

(m) *In the 70 cm band:*

(1) No amateur station shall transmit from north of Line A in the 420-430 MHz segment. See §97.3(a) for the definition of Line A.

(2) Amateur stations transmitting in the 420-430 MHz segment must not cause harmful interference to, and must accept interference from, stations authorized by the FCC in the land mobile service within 80.5 km of Buffalo, Cleveland, and Detroit. See §2.106, footnote US230 for specific frequencies and coordinates.

(3) Amateur stations transmitting in the 420-430 MHz segment or the 440-450 MHz segment must not cause harmful interference to, and must accept interference from, stations authorized by other nations in the fixed and mobile except aeronautical mobile services.

(n) *In the 33 cm band:*

(1) Amateur stations must not cause harmful interference to, and must accept interference from, stations authorized by:

(i) The United States Government;

(ii) The FCC in the Location and Monitoring Service; and

(iii) Other nations in the fixed service.

(2) No amateur station shall transmit from those portions of Texas and New Mexico that are bounded by latitudes 31°41′ and 34°30′ North and longitudes 104°11′ and 107°30′ West; or from outside of the United States and its Region 2 insular areas.

(3) No amateur station shall transmit from those portions of Colorado and Wyoming that are bounded by latitudes 39° and 42° North and longitudes 103° and 108° West in the following segments: 902.4-902.6 MHz, 904.3-904.7 MHz, 925.3-925.7 MHz, and 927.3-927.7 MHz.

(o) Amateur stations transmitting in the 23 cm band must not cause harmful interference to, and must accept interference from, stations authorized by:

(1) The United States Government in the aeronautical radionavigation, Earth exploration-satellite (active), or space research (active) services;

(2) The FCC in the aeronautical radionavigation service; and

(3) Other nations in the Earth exploration-satellite (active), radionavigation-satellite (space-to-Earth) (space-to-space), or space research (active) services.

(p) *In the 13 cm band:*

(1) Amateur stations must not cause harmful interference to, and must accept interference from, stations authorized by other nations in fixed and mobile services.

(2) Amateur stations transmitting in the 2305-2310 MHz segment must not cause harmful interference to, and must accept interference from, stations authorized by the FCC in the fixed, mobile except aeronautical mobile, and radiolocation services.

(q) Amateur stations transmitting in the 3.4-3.5 GHz segment must not cause harmful interference to, and must accept interference from, stations authorized by other nations in the fixed and fixed-satellite (space-to-Earth) services.

(r) *In the 5 cm band:*

(1) Amateur stations transmitting in the 5.650-5.725 GHz segment must not cause harmful interference to, and must accept interference from, stations authorized by other nations in the mobile except aeronautical mobile service.

(2) Amateur stations transmitting in the 5.850-5.925 GHz segment must not cause harmful interference to, and must accept interference from, stations authorized by the FCC and other nations in the fixed-satellite (Earth-to-space) and mobile services and also stations authorized by other nations in the fixed service. In the United States, the use of mobile service is restricted to Dedicated Short Range Communications operating in the Intelligent Transportation System.

(s) Authorization of the 76-77 GHz segment for amateur station transmissions is suspended until such time that the Commission may determine that amateur station transmissions in this segment will not pose a safety threat to vehicle radar systems operating in this segment.

(t) Amateur stations transmitting in the 2.5 mm band must not cause harmful interference to, and must accept interference from, stations authorized by the United States Government, the FCC, or other nations in the fixed, inter-satellite, or mobile services.

NOTE TO §97.303: The Table of Frequency Allocations contains the complete, unabridged, and legally binding frequency sharing requirements that pertain to the Amateur Radio Service. *See* 47 CFR 2.104, 2.105, and 2.106. The United States, Puerto Rico, and the U.S. Virgin Islands are in Region 2 and other U.S. insular areas are in either Region 2 or 3; see appendix 1 to part 97.

[75 FR 27203, May 14, 2010, as amended at 77 FR 5412, Feb. 3, 2012]

§97.305 Authorized emission types.

(a) Except as specified elsewhere in this part, an amateur station may transmit a CW emission on any frequency authorized to the control operator.

(b) A station may transmit a test emission on any frequency authorized to the control operator for brief periods for experimental purposes, except that no pulse modulation emission may be transmitted on any frequency where pulse is not specifically authorized and no SS modulation emission may be transmitted on any frequency where SS is not specifically authorized.

(c) A station may transmit the following emission types on the frequencies indicated, as authorized to the control operator, subject to the standards specified in §97.307(f) of this part.

Wavelength band	**Frequencies**	**Emission types authorized**	**Standards see §97.307(f), paragraph:**
MF:			
160 m	Entire band	RTTY, data	(3).
160 m	Entire band	Phone, image	(1), (2).
HF:			
80 m	Entire band	RTTY, data	(3), (9).
75 m	Entire band	Phone, image	(1), (2).
60 m	5.332, 5.348, 5.3585, 5.373 and 5.405 MHz	Phone, RTTY, data	(14).
40 m	7.000-7.100 MHz	RTTY, data	(3), (9)
40 m	7.075-7.100 MHz	Phone, image	(1), (2), (9), (11)
40 m	7.100-7.125 MHz	RTTY, data	(3), (9)
40 m	7.125-7.300 MHz	Phone, image	(1), (2)
30 m	Entire band	RTTY, data	(3).
20 m	14.00-14.15 MHz	RTTY, data	(3).
20 m	14.15-14.35 MHz	Phone, image	(1), (2).
17 m	18.068-18.110 MHz	RTTY, data	(3).
17 m	18.110-18.168 MHz	Phone, image	(1), (2).
15 m	21.0-21.2 MHz	RTTY, data	(3), (9).
15 m	21.20-21.45 MHz	Phone, image	(1), (2).
12 m	24.89-24.93 MHz	RTTY, data	(3).
12 m	24.93-24.99 MHz	Phone, image	(1), (2).
10 m	28.0-28.3 MHz	RTTY, data	(4).
10 m	28.3-28.5 MHz	Phone, image	(1), (2), (10).
10 m	28.5-29.0 MHz	Phone, image	(1), (2).
10 m	29.0-29.7 MHz	Phone, image	(2).
VHF:			
6 m	50.1-51.0 MHz	MCW, phone, image, RTTY, data	(2), (5).
Do	51.0-54.0 MHz	MCW, phone, image, RTTY, data, test	(2), (5), (8).
2 m	144.1-148.0 MHz	MCW, phone, image, RTTY, data, test	(2), (5), (8).
1.25 m	219-220 MHz	Data	(13)
Do	222-225 MHz	RTTY, data, test MCW, phone, SS, image	(2), (6), (8)
UHF:			
70 cm	Entire band	MCW, phone, image, RTTY, data, SS, test	(6), (8).
33 cm	Entire band	MCW, phone, image, RTTY, data, SS, test, pulse	(7), (8), and (12).
23 cm	Entire band	MCW, phone, image, RTTY, data, SS, test	(7), (8), and (12).
13 cm	Entire band	MCW, phone, image, RTTY, data, SS, test, pulse	(7), (8), and (12).
SHF:			

9 cm	Entire band	MCW, phone, image, RTTY, data, SS, test, pulse	(7), (8), and (12).
5 cm	Entire band	MCW, phone, image, RTTY, data, SS, test, pulse	(7), (8), and (12).
3 cm	Entire band	MCW, phone, image, RTTY, data, SS, test	(7), (8), and (12).
1.2 cm	Entire band	MCW, phone, image, RTTY, data, SS, test, pulse	(7), (8), and (12).
EHF:			
6 mm	Entire band	MCW, phone, image, RTTY, data, SS, test, pulse	(7), (8), and (12).
4 mm	Entire band	MCW, phone, image, RTTY, data, SS, test, pulse	(7), (8), and (12).
2.5 mm	Entire band	MCW, phone, image, RTTY, data, SS, test, pulse	(7), (8), and (12).
2 mm	Entire band	MCW, phone, image, RTTY, data, SS, test, pulse	(7), (8), and (12).
1mm	Entire band	MCW, phone, image, RTTY, data, SS, test, pulse	(7), (8), and (12).
	Above 275 GHz	MCW, phone, image, RTTY, data, SS, test, pulse	(7), (8), and (12).

[54 FR 25857, June 20, 1989; 54 FR 39536, Sept. 27, 1989; 55 FR 22013, May 30, 1990, as amended at 55 FR 30457, July 26, 1990; 60 FR 15688, Mar. 27, 1995; 64 FR 51471, Sept. 23, 1999; 71 FR 66465, Nov. 15, 2006; 75 FR 27204, May 14, 2010; 77 FR 5412, Feb. 3, 2012]

§97.307 Emission standards.

(a) No amateur station transmission shall occupy more bandwidth than necessary for the information rate and emission type being transmitted, in accordance with good amateur practice.

(b) Emissions resulting from modulation must be confined to the band or segment available to the control operator. Emissions outside the necessary bandwidth must not cause splatter or keyclick interference to operations on adjacent frequencies.

(c) All spurious emissions from a station transmitter must be reduced to the greatest extent practicable. If any spurious emission, including chassis or power line radiation, causes harmful interference to the reception of another radio station, the licensee of the interfering amateur station is required to take steps to eliminate the interference, in accordance with good engineering practice.

(d) For transmitters installed after January 1, 2003, the mean power of any spurious emission from a station transmitter or external RF power amplifier transmitting on a frequency below 30 MHz must be at least 43 dB below the mean power of the fundamental emission. For transmitters installed on or before January 1, 2003, the mean power of any spurious emission from a station transmitter or external RF power amplifier transmitting on a frequency below 30 MHz must not exceed 50 mW and must be at least 40 dB below the mean power of the fundamental emission. For a transmitter of mean power less than 5 W installed on or before January 1, 2003, the attenuation must be at least 30 dB. A transmitter built before April 15, 1977, or first marketed before January 1, 1978, is exempt from this requirement.

(e) The mean power of any spurious emission from a station transmitter or external RF power amplifier transmitting on a frequency between 30-225 MHz must be at least 60 dB below the mean power of the fundamental. For a transmitter having a mean power of 25 W or less, the mean power of any spurious emission supplied to the antenna transmission line must not exceed 25 μW and must be at least 40 dB below the mean power of the fundamental emission, but need not be reduced below the power of 10 μW. A transmitter built before April 15, 1977, or first marketed before January 1, 1978, is exempt from this requirement.

(f) The following standards and limitations apply to transmissions on the frequencies specified in §97.305(c) of this part.

(1) No angle-modulated emission may have a modulation index greater than 1 at the highest modulation frequency.

(2) No non-phone emission shall exceed the bandwidth of a communications quality phone emission of the same modulation type. The total bandwidth of an independent sideband emission (having B as the first symbol), or a multiplexed image and phone emission, shall not exceed that of a communications quality A3E emission.

(3) Only a RTTY or data emission using a specified digital code listed in §97.309(a) of this part may be transmitted. The symbol rate must not exceed 300 bauds, or for frequency-shift keying, the frequency shift between mark and space must not exceed 1 kHz.

(4) Only a RTTY or data emission using a specified digital code listed in §97.309(a) of this part may be transmitted. The symbol rate must not exceed 1200 bauds, or for frequency-shift keying, the frequency shift between mark and space must not exceed 1 kHz.

(5) A RTTY, data or multiplexed emission using a specified digital code listed in §97.309(a) of this part may be transmitted. The symbol rate must not exceed 19.6 kilobauds. A RTTY, data or multiplexed emission using an unspecified digital code under the limitations listed in §97.309(b) of this part also may be transmitted. The authorized bandwidth is 20 kHz.

(6) A RTTY, data or multiplexed emission using a specified digital code listed in §97.309(a) of this part may be transmitted. The symbol rate must not exceed 56 kilobauds. A RTTY, data or multiplexed emission using an unspecified digital code under the limitations listed in §97.309(b) of this part also may be transmitted. The authorized bandwidth is 100 kHz.

(7) A RTTY, data or multiplexed emission using a specified digital code listed in §97.309(a) of this part or an unspecified digital code under the limitations listed in §97.309(b) of this part may be transmitted.

(8) A RTTY or data emission having designators with A, B, C, D, E, F, G, H, J or R as the first symbol; 1, 2, 7, 9 or X as the second symbol; and D or W as the third symbol is also authorized.

(9) A station having a control operator holding a Novice or Technician Class operator license may only transmit a CW emission using the international Morse code.

(10) A station having a control operator holding a Novice Class operator license or a Technician Class operator license and who has received credit for proficiency in telegraphy in accordance with the international requirements may only transmit a CW emission using the international Morse code or phone emissions J3E and R3E.

(11) Phone and image emissions may be transmitted only by stations located in ITU Regions 1 and 3, and by stations located within ITU Region 2 that are west of 130° West longitude or south of 20° North latitude.

(12) Emission F8E may be transmitted.

(13) A data emission using an unspecified digital code under the limitations listed in §97.309(b) also may be transmitted. The authorized bandwidth is 100 kHz.

(14) *In the 60 m band:*

(i) A station may transmit only phone, RTTY, data, and CW emissions using the emission designators and any additional restrictions that are specified in the table below (except that the use of a narrower necessary bandwidth is permitted):

60 M BAND EMISSION REQUIREMENTS

Emission type	Emission designator	Restricted to:
Phone	2K80J3E	Upper sideband transmissions (USB).
Data	2K80J2D	USB (for example, PACTOR-III).
RTTY	60H0J2B	USB (for example, PSK31).
CW	150HA1A	Morse telegraphy by means of on-off keying.

(ii) The following requirements also apply:

(A) When transmitting the phone, RTTY, and data emissions, the suppressed carrier frequency may be set as specified in §97.303(h).

(B) The control operator of a station transmitting data or RTTY emissions must exercise care to limit the length of transmission so as to avoid causing harmful interference to United States Government stations.

[54 FR 25857, June 20, 1989; 54 FR 30823, July 24, 1989, as amended at 54 FR 39537, Sept. 27, 1989; 60 FR 15688, Mar. 27, 1995; 65 FR 6550, Feb. 10, 2000; 69 FR 24997, May 5, 2004; 77 FR 5412, Feb. 3, 2012; 79 FR 35291, June 20, 2014]

§97.309 RTTY and data emission codes.

(a) Where authorized by §§97.305(c) and 97.307(f) of the part, an amateur station may transmit a RTTY or data emission using the following specified digital codes:

(1) The 5-unit, start-stop, International Telegraph Alphabet No. 2, code defined in ITU-T Recommendation F.1, Division C (commonly known as “Baudot”).

(2) The 7-unit code specified in ITU-R Recommendations M.476-5 and M.625-3 (commonly known as “AMTOR”).

(3) The 7-unit, International Alphabet No. 5, code defined in IT--T Recommendation T.50 (commonly known as “ASCII”).

(4) An amateur station transmitting a RTTY or data emission using a digital code specified in this paragraph may use any technique whose technical characteristics have been documented publicly, such as CLOVER, G-TOR, or PacTOR, for the purpose of facilitating communications.

(b) Where authorized by §§97.305(c) and 97.307(f) of this part, a station may transmit a RTTY or data emission using an unspecified digital code, except to a station in a country with which the United States does not have an agreement permitting the code to be used. RTTY and data emissions using unspecified digital codes must not be transmitted for the purpose of obscuring the meaning of any communication. When deemed necessary by a District Director to assure compliance with the FCC Rules, a station must:

(1) Cease the transmission using the unspecified digital code;

(2) Restrict transmissions of any digital code to the extent instructed;

(3) Maintain a record, convertible to the original information, of all digital communications transmitted.

[54 FR 25857, June 20, 1989, as amended at 54 FR 39537, Sept. 27, 1989; 56 FR 56172, Nov. 1, 1991; 60 FR 55486, Nov. 1, 1995; 71 FR 25982, May 3, 2006; 71 FR 66465, Nov. 15, 2006]

§97.311 SS emission types.

(a) SS emission transmissions by an amateur station are authorized only for communications between points within areas where the amateur service is regulated by the FCC and between an area where the amateur service is regulated by the FCC and an amateur station in another country that permits such communications. SS emission transmissions must not be used for the purpose of obscuring the meaning of any communication.

(b) A station transmitting SS emissions must not cause harmful interference to stations employing other authorized emissions, and must accept all interference caused by stations employing other authorized emissions.

(c) When deemed necessary by a District Director to assure compliance with this part, a station licensee must:

(1) Cease SS emission transmissions;

(2) Restrict SS emission transmissions to the extent instructed; and

(3) Maintain a record, convertible to the original information (voice, text, image, etc.) of all spread spectrum communications transmitted.

[64 FR 51471, Sept. 23, 1999, as amended at 76 FR 17569, Mar. 30, 2011]

§97.313 Transmitter power standards.

(a) An amateur station must use the minimum transmitter power necessary to carry out the desired communications.

(b) No station may transmit with a transmitter power exceeding 1.5 kW PEP.

(c) No station may transmit with a transmitter power output exceeding 200 W PEP:

(1) On the 10.10-10.15 MHz segment;

(2) On the 3.525-3.60 MHz, 7.025-7.125 MHz, 21.025-21.20 MHz, and 28.0-28.5 MHz segment when the control operator is a Novice Class operator or a Technician Class operator; or

(3) The 7.050-7.075 MHz segment when the station is within ITU Regions 1 or 3.

(d) No station may transmit with a transmitter power exceeding 25 W PEP on the VHF 1.25 m band when the control operator is a Novice operator.

(e) No station may transmit with a transmitter power exceeding 5 W PEP on the UHF 23 cm band when the control operator is a Novice operator.

(f) No station may transmit with a transmitter power exceeding 50 W PEP on the UHF 70 cm band from an area specified in paragraph (a) of footnote US270 in §2.106, unless expressly authorized by the FCC after mutual agreement, on a case-by-case basis, between the District Director of the applicable field facility and the military area frequency coordinator at the applicable military base. An Earth station or telecommand station, however, may transmit on the 435-438 MHz segment with a maximum of 611 W effective radiated power (1 kW equivalent isotropically radiated power) without the authorization otherwise required. The transmitting antenna elevation angle between the lower half-power (−3 dB relative to the peak or antenna bore sight) point and the horizon must always be greater than 10°.

(g) No station may transmit with a transmitter power exceeding 50 W PEP on the 33 cm band from within 241 km of the boundaries of the White Sands Missile Range. Its boundaries are those portions of Texas and New Mexico bounded on the south by latitude 31°41′ North, on the east by longitude 104°11′ West, on the north by latitude 34°30′ North, and on the west by longitude 107°30′ West.

(h) No station may transmit with a transmitter power exceeding 50 W PEP on the 219-220 MHz segment of the 1.25 m band.

(i) No station may transmit with an effective radiated power (ERP) exceeding 100 W PEP on the 60 m band. For the purpose of computing ERP, the transmitter PEP will be multiplied by the antenna gain relative to a half-wave dipole antenna. A half-wave dipole antenna will be presumed to have a gain of 1 (0 dBd). Licensees using other antennas must maintain in their station records either the antenna manufacturer's data on the antenna gain or calculations of the antenna gain.

(j) No station may transmit with a transmitter output exceeding 10 W PEP when the station is transmitting a SS emission type.

[54 FR 25857, June 20, 1989, as amended at 56 FR 37161, Aug. 5, 1991; 56 FR 3043, Jan. 28, 1991; 60 FR 15688, Mar. 27, 1995; 65 FR 6550, Feb. 10, 2000; 71 FR 66465, Nov. 15, 2006; 75 FR 27204, May 14, 2010; 75 FR 78171, Dec. 15, 2010; 76 FR 17569, Mar. 30, 2011; 77 FR 5413, Feb. 3, 2012]

§97.315 Certification of external RF power amplifiers.

(a) Any external RF power amplifier (see §2.815 of the FCC Rules) manufactured or imported for use at an amateur radio station must be certificated for use in the amateur service in accordance with subpart J of part 2 of the FCC Rules. No amplifier capable of operation below 144 MHz may be constructed or modified by a non-amateur service licensee without a grant of certification from the FCC.

(b) The requirement of paragraph (a) does not apply if one or more of the following conditions are met:

(1) The amplifier is constructed or modified by an amateur radio operator for use at an amateur station.

(2) The amplifier was manufactured before April 28, 1978, and has been issued a marketing waiver by the FCC, or the amplifier was purchased before April 28, 1978, by an amateur radio operator for use at that operator's station.

(3) The amplifier is sold to an amateur radio operator or to a dealer, the amplifier is purchased in used condition by a dealer, or the amplifier is sold to an amateur radio operator for use at that operator's station.

(c) Any external RF power amplifier appearing in the Commission's database as certificated for use in the amateur service may be marketed for use in the amateur service.

[71 FR 66465, Nov. 15, 2006]

§97.317 Standards for certification of external RF power amplifiers.

(a) To receive a grant of certification, the amplifier must:

(1) Satisfy the spurious emission standards of §97.307 (d) or (e) of this part, as applicable, when the amplifier is operated at the lesser of 1.5 kW PEP or its full output power and when the amplifier is placed in the “standby” or “off” positions while connected to the transmitter.

(2) Not be capable of amplifying the input RF power (driving signal) by more than 15 dB gain. Gain is defined as the ratio of the input RF power to the output RF power of the amplifier where both power measurements are expressed in peak envelope power or mean power.

(3) Exhibit no amplification (0 dB gain) between 26 MHz and 28 MHz.

(b) Certification shall be denied when:

(1) The Commission determines the amplifier can be used in services other than the Amateur Radio Service, or

(2) The amplifier can be easily modified to operate on frequencies between 26 MHz and 28 MHz.

[71 FR 66465, Nov. 15, 2006]

Subpart E—Providing Emergency Communications

§97.401 Operation during a disaster.

A station in, or within 92.6 km (50 nautical miles) of, Alaska may transmit emissions J3E and R3E on the channel at 5.1675 MHz (assigned frequency 5.1689 MHz) for emergency communications. The channel must be shared with stations licensed in the Alaska-Private Fixed Service. The

transmitter power must not exceed 150 W PEP. A station in, or within 92.6 km of, Alaska may transmit communications for tests and training drills necessary to ensure the establishment, operation, and maintenance of emergency communication systems.

[71 FR 66465, Nov. 15, 2006]

§97.403 Safety of life and protection of property.

No provision of these rules prevents the use by an amateur station of any means of radiocommunication at its disposal to provide essential communication needs in connection with the immediate safety of human life and immediate protection of property when normal communication systems are not available.

§97.405 Station in distress.

(a) No provision of these rules prevents the use by an amateur station in distress of any means at its disposal to attract attention, make known its condition and location, and obtain assistance.

(b) No provision of these rules prevents the use by a station, in the exceptional circumstances described in paragraph (a) of this section, of any means of radiocommunications at its disposal to assist a station in distress.

§97.407 Radio amateur civil emergency service.

(a) No station may transmit in RACES unless it is an FCC-licensed primary, club, or military recreation station and it is certified by a civil defense organization as registered with that organization. No person may be the control operator of an amateur station transmitting in RACES unless that person holds a FCC-issued amateur operator license and is certified by a civil defense organization as enrolled in that organization.

(b) The frequency bands and segments and emissions authorized to the control operator are available to stations transmitting communications in RACES on a shared basis with the amateur service. In the event of an emergency which necessitates invoking the President's War Emergency Powers under the provisions of section 706 of the Communications Act of 1934, as amended, 47 U.S.C. 606, amateur stations participating in RACES may only transmit on the frequency segments authorized pursuant to part 214 of this chapter.

(c) An amateur station registered with a civil defense organization may only communicate with the following stations upon authorization of the responsible civil defense official for the organization with which the amateur station is registered:

(1) An amateur station registered with the same or another civil defense organization; and

(2) A station in a service regulated by the FCC whenever such communication is authorized by the FCC.

(d) All communications transmitted in RACES must be specifically authorized by the civil defense organization for the area served. Only civil defense communications of the following types may be transmitted:

(1) Messages concerning impending or actual conditions jeopardizing the public safety, or affecting the national defense or security during periods of local, regional, or national civil emergencies;

(2) Messages directly concerning the immediate safety of life of individuals, the immediate protection of property, maintenance of law and order, alleviation of human suffering and need, and the combating of armed attack or sabotage;

(3) Messages directly concerning the accumulation and dissemination of public information or instructions to the civilian population essential to the activities of the civil defense organization or other authorized governmental or relief agencies; and

(4) Communications for RACES training drills and tests necessary to ensure the establishment and maintenance of orderly and efficient operation of the RACES as ordered by the responsible civil defense organization served. Such drills and tests may not exceed a total time of 1 hour per week. With the approval of the chief officer for emergency planning in the applicable State, Commonwealth, District or territory, however, such tests and drills may be conducted for a period not to exceed 72 hours no more than twice in any calendar year.

[75 FR 78171, Dec. 15, 2010]

Subpart F—Qualifying Examination Systems

§97.501 Qualifying for an amateur operator license.

Each applicant must pass an examination for a new amateur operator license grant and for each change in operator class. Each applicant for the class of operator license grant specified below must pass, or otherwise receive examination credit for, the following examination elements:

(a) Amateur Extra Class operator: Elements 2, 3, and 4;

(b) General Class operator: Elements 2 and 3;

(c) Technician Class operator: Element 2.

[65 FR 6550, Feb. 10, 2000, as amended at 72 FR 3082, Jan. 24, 2007]

§97.503 Element standards.

A written examination must be such as to prove that the examinee possesses the operational and technical qualifications required to perform properly the duties of an amateur service licensee. Each written examination must be comprised of a question set as follows:

(a) Element 2: 35 questions concerning the privileges of a Technician Class operator license. The minimum passing score is 26 questions answered correctly.

(b) Element 3: 35 questions concerning the privileges of a General Class operator license. The minimum passing score is 26 questions answered correctly.

(c) Element 4: 50 questions concerning the privileges of an Amateur Extra Class operator license. The minimum passing score is 37 questions answered correctly.

[54 FR 25857, June 20, 1989, as amended at 61 FR 41019, Aug. 7, 1996; 65 FR 6550, Feb. 10, 2000; 72 FR 3082, Jan. 24, 2007]

§97.505 Element credit.

(a) The administering VEs must give credit as specified below to an examinee holding any of the following license grants:

Operator class	Unexpired (or within the renewal grace period)	Expired and beyond the renewal grace period
(1) Amateur Extra	Not applicable	Elements 3 and 4.
(2) Advanced; General; or Technician granted before March 21, 1987	Elements 2 and 3	Element 3.
(3) Technician Plus; or Technician granted on or after March 21, 1987	Element 2	No credit.

(b) The administering VEs must give credit to an examinee holding a CSCE for each element the CSCE indicates the examinee passed within the previous 365 days.

[79 FR 35291, June 20, 2014]

§97.507 Preparing an examination.

(a) Each written question set administered to an examinee must be prepared by a VE holding an Amateur Extra Class operator license. A written question set may also be prepared for the following elements by a VE holding an operator license of the class indicated:

(1) Element 3: Advanced Class operator.

(2) Element 2: Advanced or General class operators.

(b) Each question set administered to an examinee must utilize questions taken from the applicable question pool.

(c) Each written question set administered to an examinee for an amateur operator license must be prepared, or obtained from a supplier, by the administering VEs according to instructions from the coordinating VEC.

[54 FR 25857, June 20, 1989, as amended at 58 FR 29126, May 19, 1993; 59 FR 54834, Nov. 2, 1994; 65 FR 6551, Feb. 10, 2000; 69 FR 24997, May 5, 2004; 79 FR 35291, June 20, 2014; 79 FR 52226, Sept. 3, 2014]

§97.509 Administering VE requirements.

(a) Each examination for an amateur operator license must be administered by a team of at least 3 VEs at an examination session coordinated by a VEC. The number of examinees at the session may be limited.

(b) Each administering VE must:

(1) Be accredited by the coordinating VEC;

(2) Be at least 18 years of age;

(3) Be a person who holds an amateur operator license of the class specified below:

(i) Amateur Extra, Advanced or General Class in order to administer a Technician Class operator license examination;

(ii) Amateur Extra or Advanced Class in order to administer a General Class operator license examination;

(iii) Amateur Extra Class in order to administer an Amateur Extra Class operator license examination.

(4) Not be a person whose grant of an amateur station license or amateur operator license has ever been revoked or suspended.

(c) Each administering VE must observe the examinee throughout the entire examination. The administering VEs are responsible for the proper conduct and necessary supervision of each examination. The administering VEs must immediately terminate the examination upon failure of the examinee to comply with their instructions.

(d) No VE may administer an examination to his or her spouse, children, grandchildren, stepchildren, parents, grandparents, stepparents, brothers, sisters, stepbrothers, stepsisters, aunts, uncles, nieces, nephews, and in-laws.

(e) No VE may administer or certify any examination by fraudulent means or for monetary or other consideration including reimbursement in any amount in excess of that permitted. Violation of this provision may result in the revocation of the grant of the VE's amateur station license and the suspension of the grant of the VE's amateur operator license.

(f) No examination that has been compromised shall be administered to any examinee. The same question set may not be re-administered to the same examinee.

(g) [Reserved]

(h) Upon completion of each examination element, the administering VEs must immediately grade the examinee's answers. For examinations administered remotely, the administering VEs must grade the examinee's answers at the earliest practical opportunity. The administering VEs are responsible for determining the correctness of the examinee's answers.

(i) When the examinee is credited for all examination elements required for the operator license sought, 3 VEs must certify that the examinee is qualified for the license grant and that the VEs have complied with these administering VE requirements. The certifying VEs are jointly and individually accountable for the proper administration of each examination element reported. The certifying VEs may delegate to other qualified VEs their authority, but not their accountability, to administer individual elements of an examination.

(j) When the examinee does not score a passing grade on an examination element, the administering VEs must return the application document to the examinee and inform the examinee of the grade.

(k) The administering VEs must accommodate an examinee whose physical disabilities require a special examination procedure. The administering VEs may require a physician's certification indicating the nature of the disability before determining which, if any, special procedures must be used.

(l) The administering VEs must issue a CSCE to an examinee who scores a passing grade on an examination element.

(m) After the administration of a successful examination for an amateur operator license, the administering VEs must submit the application document to the coordinating VEC according to the coordinating VEC's instructions.

[59 FR 54834, Nov. 2, 1994, as amended at 61 FR 9953, Mar. 12, 1996; 62 FR 17567, Apr. 10, 1997; 63 FR 68980, Dec. 14, 1998; 65 FR 6551, Feb. 10, 2000; 71 FR 66465, Nov. 15, 2006; 79 FR 35291. June 20, 2014]

§97.511 Examinee conduct.

Each examinee must comply with the instructions given by the administering VEs.

[59 FR 54835, Nov. 2, 1994]

§97.513 VE session manager requirements.

(a) A VE session manager may be selected by the VE team for each examination session. The VE session manager must be accredited as a VE by the same VEC that coordinates the examination session. The VE session manager may serve concurrently as an administering VE.

(b) The VE session manager may carry on liaison functions between the VE team and the coordinating VEC.

(c) The VE session manager may organize activities at an examination session.

[62 FR 17567, Apr. 10, 1997, as amended at 79 FR 35291, June 20, 2014]

§§97.515-97.517 [Reserved]

§97.519 Coordinating examination sessions.

(a) A VEC must coordinate the efforts of VEs in preparing and administering examinations.

(b) At the completion of each examination session, the coordinating VEC must collect applicant information and test results from the administering VEs. The coordinating VEC must:

(1) Screen collected information;

(2) Resolve all discrepancies and verify that the VEs' certifications are properly completed; and

(3) For qualified examinees, forward electronically all required data to the FCC. All data forwarded must be retained for at least 15 months and must be made available to the FCC upon request.

(c) Each VEC must make any examination records available to the FCC, upon request

(d) The FCC may:

(1) Administer any examination element itself;

(2) Readminister any examination element previously administered by VEs, either itself or under the supervision of a VEC or VEs designated by the FCC; or

(3) Cancel the operator/primary station license of any licensee who fails to appear for readministration of an examination when directed by the FCC, or who does not successfully complete any required element that is readministered. In an instancce of such cancellation, the person will be granted an operator/primary station license consistent with completed examination elements that have not been invalidated by not appearing for, or by failing, the examination upon readministration.

[54 FR 25857, June 20, 1989, as amended at 59 FR 54835, Nov. 2, 1994; 62 FR 17567, Apr. 10, 1997; 63 FR 68981, Dec. 14, 1998; 71 FR 66465, Nov. 15, 2006; 79 FR 35291, June 20, 2014]

§97.521 VEC qualifications.

No organization may serve as a VEC unless it has entered into a written agreement with the FCC. The VEC must abide by the terms of the agreement. In order to be eligible to be a VEC, the entity must:

(a) Be an organization that exists for the purpose of furthering the amateur service;

(b) Be capable of serving as a VEC in at least the VEC region (see appendix 2) proposed;

(c) Agree to coordinate examinations for any class of amateur operator license;

(d) Agree to assure that, for any examination, every examinee qualified under these rules is registered without regard to race, sex, religion, national origin or membership (or lack thereof) in any amateur service organization;

[54 FR 25857, June 20, 1989, as amended at 58 FR 29127, May 19, 1993; 61 FR 9953, Mar. 12, 1996]

§97.523 Question pools.

All VECs must cooperate in maintaining one question pool for each written examination element. Each question pool must contain at least 10 times the number of questions required for a single examination. Each question pool must be published and made available to the public prior to its use for making a question set. Each question on each VEC question pool must be prepared by a VE holding the required FCC-issued operator license. See §97.507(a) of this part.

§97.525 Accrediting VEs.

(a) No VEC may accredit a person as a VE if:

(1) The person does not meet minimum VE statutory qualifications or minimum qualifications as prescribed by this part;

(2) The FCC does not accept the voluntary and uncompensated services of the person;

(3) The VEC determines that the person is not competent to perform the VE functions; or

(4) The VEC determines that questions of the person's integrity or honesty could compromise the examinations.

(b) Each VEC must seek a broad representation of amateur operators to be VEs. No VEC may discriminate in accrediting VEs on the basis of race, sex, religion or national origin; nor on the basis of membership (or lack thereof) in an amateur service organization; nor on the basis of the person accepting or declining to accept reimbursement.

§97.527 Reimbursement for expenses.

VEs and VECs may be reimbursed by examinees for out-of-pocket expenses incurred in preparing, processing, administering, or coordinating an examination for an amateur operator license.

[66 FR 20752, Apr. 25, 2001]

Appendix 1 to Part 97—Places Where the Amateur Service is Regulated by the FCC

In ITU Region 2, the amateur service is regulated by the FCC within the territorial limits of the 50 United States, District of Columbia, Caribbean Insular areas [Commonwealth of Puerto Rico, United States Virgin Islands (50 islets and cays) and Navassa Island], and Johnston Island (Islets East, Johnston, North and Sand) and Midway Island (Islets Eastern and Sand) in the Pacific Insular areas.

In ITU Region 3, the amateur service is regulated by the FCC within the Pacific Insular territorial limits of American Samoa (seven islands), Baker Island, Commonwealth of Northern Mariana Islands, Guam Island, Howland Island, Jarvis Island, Kingman Reef, Palmyra Island (more than 50 islets) and Wake Island (Islets Peale, Wake and Wilkes).

Appendix 2 to Part 97—VEC Regions

1. Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island and Vermont.

2. New Jersey and New York.

3. Delaware, District of Columbia, Maryland and Pennsylvania.

4. Alabama, Florida, Georgia, Kentucky, North Carolina, South Carolina, Tennessee and Virginia.

5. Arkansas, Louisiana, Mississippi, New Mexico, Oklahoma and Texas.

6. California.

7. Arizona, Idaho, Montana, Nevada, Oregon, Utah, Washington and Wyoming.

8. Michigan, Ohio and West Virginia.

9. Illinois, Indiana and Wisconsin.

10. Colorado, Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota and South Dakota.

11. Alaska.

12. Caribbean Insular areas.

13. Hawaii and Pacific Insular areas.

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W5YI : Part 97 : Sec. 97.303 Frequency sharing requirements

Part 97 : Sec. 97.303 Frequency sharing requirements

The following paragraphs summarize the frequency sharing requirements that apply to amateur stations transmitting in the frequency bands specified in §97.301 of this part. Each frequency band allocated to the amateur service is designated as either a secondary service or a primary service. A station in a secondary service must not cause harmful interference to, and must accept interference from, stations in a primary service.

(a) Where, in adjacent ITU Regions or sub-Regions, a band of frequencies is allocated to different services of the same category (i.e., primary or secondary services), the basic principle is the equality of right to operate. Accordingly, stations of each service in one Region or sub-Region must operate so as not to cause harmful interference to any service of the same or higher category in the other Regions or sub-Regions.

(b) Amateur stations transmitting in the 70 cm band, the 33 cm band, the 23 cm band, the 9 cm band, the 5 cm band, the 3 cm band, or the 24.05–24.25 GHz segment must not cause harmful interference to, and must accept interference from, stations authorized by the United States Government in the radiolocation service.

(c) Amateur stations transmitting in the 1900–2000 kHz segment, the 76–77.5 GHz segment, the 78–81 GHz segment, the 136–141 GHz segment, or the 241–248 GHz segment must not cause harmful interference to, and must accept interference from, stations authorized by the United States Government, the FCC, or other nations in the radiolocation service.

(d) Amateur stations transmitting in the 430–450 MHz segment, the 23 cm band, the 3.3–3.4 GHz segment, the 5.65–5.85 GHz segment, the 13 cm band, or the 24.05–24.25 GHz segment, must not cause harmful interference to, and must accept interference from, stations authorized by other nations in the radiolocation service.

(e) Amateur stations receiving in the 33 cm band, the 2400–2450 MHz segment, the 5.725–5.875 GHz segment, the 1.2 cm band, the 2.5 mm band, or the 244–246 GHz segment must accept interference from industrial, scientific, and medical (ISM) equipment.

(f) Amateur stations transmitting in the following segments must not cause harmful interference to radio astronomy stations: 3.332–3.339 GHz, 3.3458–3.3525 GHz, 76–77.5 GHz, 78–81 GHz, 136–141 GHz, 241–248 GHz, 275–323 GHz, 327–371 GHz, 388–424 GHz, 426–442 GHz, 453–510 GHz, 623–711 GHz, 795–909 GHz, or 926–945 GHz. In addition, amateur stations transmitting in the following segments must not cause harmful interference to stations in the Earth exploration-satellite service (passive) or the space research service (passive): 275–277 GHz, 294–306 GHz, 316–334 GHz, 342–349 GHz, 363–365 GHz, 371–389 GHz, 416–434 GHz, 442–444 GHz, 496–506 GHz, 546–568 GHz, 624–629 GHz, 634–654 GHz, 659–661 GHz, 684–692 GHz, 730–732 GHz, 851–853 GHz, or 951–956 GHz.

(g) Amateur stations transmitting in the 1900–2000 kHz segment must not cause harmful interference to, and must accept interference from, stations authorized by other nations in the fixed, mobile except aeronautical mobile, and radionavigation services.

(h) Amateur stations may only transmit single sideband, suppressed carrier (emission type 2K80J3E), upper sideband on the channels 5332 kHz, 5348 kHz, 5368 kHz, 5373 kHz, and 5405 kHz. Amateur operators shall ensure that their station's transmission occupies only 2.8 kHz centered at each of these frequencies. Amateur stations must not cause harmful interference to, and must accept interference from, stations authorized by:

(1) The United States Government, the FCC, or other nations in the fixed service; and

(2) Other nations in the mobile except aeronautical mobile service.

(i) Amateur stations transmitting in the 7.2–7.3 MHz segment must not cause harmful interference to, and must accept interference from, international broadcast stations whose programming is intended for use within Region 1 or Region 3.

(j) Amateur stations transmitting in the 30 m band must not cause harmful interference to, and must accept interference from, stations by other nations in the fixed service. The licensee of the amateur station must make

all necessary adjustments, including termination of transmissions, if harmful interference is caused.

(k) For amateur stations located in ITU Regions 1 and 3: Amateur stations transmitting in the 146–148 MHz segment or the 10.00–10.45 GHz segment must not cause harmful interference to, and must accept interference from, stations of other nations in the fixed and mobile services.

(l) In the 219–220 MHz segment:

(1) Use is restricted to amateur stations participating as forwarding stations in fixed point-to-point digital message forwarding systems, including intercity packet backbone networks. It is not available for other purposes.

(2) Amateur stations must not cause harmful interference to, and must accept interference from, stations authorized by:

(i) The FCC in the Automated Maritime Telecommunications System (AMTS), the 218–219 MHz Service, and the 220 MHz Service, and television stations broadcasting on channels 11 and 13; and

(ii) Other nations in the fixed and maritime mobile services.

(3) No amateur station may transmit unless the licensee has given written notification of the station's specific geographic location for such transmissions in order to be incorporated into a database that has been made available to the public. The notification must be given at least 30 days prior to making such transmissions. The notification must be given to: The American Radio Relay League, Inc., 225 Main Street, Newington, CT 06111–1494.

(4) No amateur station may transmit from a location that is within 640 km of an AMTS coast station that operates in the 217–218 MHz and 219–220 MHz bands unless the amateur station licensee has given written notification of the station's specific geographic location for such transmissions to the AMTS licensee. The notification must be given at least 30 days prior to making such transmissions. The location of AMTS coast stations using the 217–218/219–220 MHz channels may be obtained as noted in paragraph (l)(3) of this section.

(5) No amateur station may transmit from a location that is within 80 km of an AMTS coast station that uses frequencies in the 217–218 MHz and 219–220 MHz bands unless that amateur station licensee holds written approval from that AMTS licensee. The location of AMTS coast stations using the 217–218/219–220 MHz channels may be obtained as noted in paragraph (l)(3) of this section.

(m) In the 70 cm band:

(1) No amateur station shall transmit from north of Line A in the 420–430 MHz segment. See §97.3(a) for the definition of Line A.

(2) Amateur stations transmitting in the 420–430 MHz segment must not cause harmful interference to, and must accept interference from, stations authorized by the FCC in the land mobile service within 80.5 km of Buffalo, Cleveland, and Detroit. See §2.106, footnote US230 for specific frequencies and coordinates.

(3) Amateur stations transmitting in the 420–430 MHz segment or the 440–450 MHz segment must not cause harmful interference to, and must accept interference from, stations authorized by other nations in the fixed and mobile except aeronautical mobile services.

(n) In the 33 cm band:

(1) Amateur stations must not cause harmful interference to, and must accept interference from, stations authorized by:

(i) The United States Government;

(ii) The FCC in the Location and Monitoring Service; and

(iii) Other nations in the fixed service.

(2) No amateur station shall transmit from those portions of Texas and New Mexico that are bounded by latitudes 31°41' and 34°30' North and longitudes 104°11' and 107°30' West; or from outside of the United States and its Region 2 insular areas.

(3) No amateur station shall transmit from those portions of Colorado and Wyoming that are bounded by latitudes 39° and 42° North and longitudes 103° and 108° West in the following segments: 902.4–902.6 MHz, 904.3–904.7 MHz, 925.3–925.7 MHz, and 927.3–927.7 MHz.

(o) Amateur stations transmitting in the 23 cm band must not cause harmful interference to, and must accept interference from, stations authorized by:

(1) The United States Government in the aeronautical radionavigation, Earth exploration-satellite (active), or space research (active) services;

(2) The FCC in the aeronautical radionavigation service; and

(3) Other nations in the Earth exploration-satellite (active), radionavigation-satellite (space-to-Earth) (space-to-space), or space research (active) services.

(p) In the 13 cm band:

(1) Amateur stations must not cause harmful interference to, and must accept interference from, stations authorized by other nations in fixed and mobile services.

(2) Amateur stations transmitting in the 2305–2310 MHz segment must not cause harmful interference to, and must accept interference from, stations authorized by the FCC in the fixed, mobile except aeronautical mobile, and radiolocation services.

(q) Amateur stations transmitting in the 3.4–3.5 GHz segment must not cause harmful interference to, and must accept interference from, stations authorized by other nations in the fixed and fixed-satellite (space-to-Earth) services.

(r) In the 5 cm band:

(1) Amateur stations transmitting in the 5.650–5.725 GHz segment must not cause harmful interference to, and must accept interference from, stations authorized by other nations in the mobile except aeronautical mobile service.

(2) Amateur stations transmitting in the 5.850–5.925 GHz segment must not cause harmful interference to, and must accept interference from, stations authorized by the FCC and other nations in the fixed-satellite (Earth-to-space) and mobile services and also stations authorized by other nations in the fixed service. In the United States, the use of mobile service is restricted to Dedicated Short Range Communications operating in the Intelligent Transportation System.

(s) Authorization of the 76–77 GHz segment for amateur station transmissions is suspended until such time that the Commission may determine that amateur station transmissions in this segment will not pose a safety threat to vehicle radar systems operating in this segment.

(t) Amateur stations transmitting in the 2.5 mm band must not cause harmful interference to, and must accept interference from, stations authorized by the United States Government, the FCC, or other nations in the fixed, inter-satellite, or mobile services.

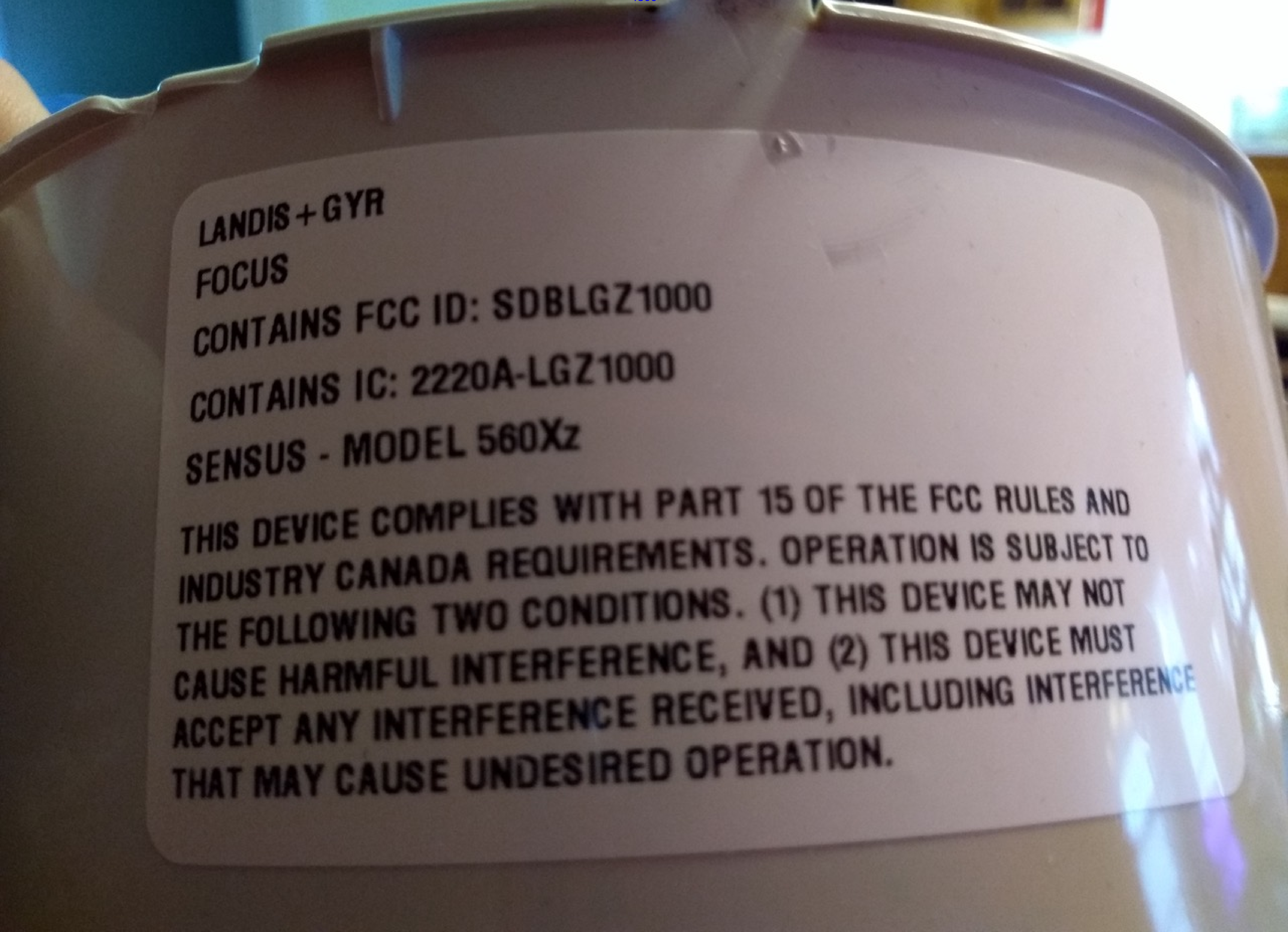
Note to §97.303: The Table of Frequency Allocations contains the complete, unabridged, and legally binding frequency sharing requirements that pertain to the Amateur Radio Service. See 47 CFR 2.104, 2.105, and 2.106. The United States, Puerto Rico, and the U.S. Virgin Islands are in Region 2 and other U.S. insular areas are in either Region 2 or 3; see appendix 1 to part 97.

[75 FR 27203, May 14, 2010]

Return to Part 97

- Service Disconnect/Reconnect Commands for 0.5% of residential advanced electric meters population per day (which includes prepay customers)
- Meter configuration for 0.5% of electric population per day
- Firmware downloads for electric population twice yearly
- Advanced meter change outs for 0.1% of electric population per day
- Meter Events pushed for 1.0% of advanced electric endpoint population per day (Tamper Alarms, Quality of Service Alarms)
- Endpoints communicate to other endpoints and Routers at up to 115.2 kbps
- Routers communicate to other Routers and Collectors at up to 115.2 kbps

- The following are standard Propagation parameters:
  - The antenna for C6500 Series Collector is installed at a minimum of 20 feet above ground level (AGL) on poles and a minimum of 45 feet if installed at a substation
  - As a standard, Router antennas are installed at a minimum of 20 feet AGL
  - Typical design communication ranges for endpoint to endpoint communication is up to 1,400 feet
  - Typical Router to endpoint communication is up to 2,300 feet
  - Typical Router to Router communication is a half mile to two (2) miles depending on standard power output, antenna, foliage, buildings, and terrain


LANDIS+GYR
FOCUS
CONTAINS FCC ID: SDBLGZ1000
CONTAINS IC: 2220A-LGZ1000
SENSUS - MODEL 560Xz
THIS DEVICE COMPLIES WITH PART 15 OF THE FCC RULES AND INDUSTRY CANADA REQUIREMENTS. OPERATION IS SUBJECT TO THE FOLLOWING TWO CONDITIONS. (1) THIS DEVICE MAY NOT CAUSE HARMFUL INTERFERENCE, AND (2) THIS DEVICE MUST ACCEPT ANY INTERFERENCE RECEIVED, INCLUDING INTERFERENCE THAT MAY CAUSE UNDESIRED OPERATION.

VE3NCQ

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Smart Meter Interference

Assessment of Chatham-Kent Hydro Smart Meter Implementation

This paper has become one of the highest ranked resources on the web addressing Smart Meter interference problems. This article has been updated to incorporate new research.

Background

Chatham-Kent Energy has recently installed a number of Smart Meters, with the goal of having all 32,000 customers serviced by these devices prior to the December 31, 2010 provincial deadline. Chatham-Kent Energy has been noticed within the industry as taking a lead while at the same time reducing costs considerably, claiming other utilities are looking to emulate this success.

The total cost of introducing Smart Meters is estimated at $4,638,425, including the TUNet modules used inside the meters. This is funded by Hydro customers.

While we must applaud the Smart Meter initiative, and be proud of our leading role in introducing this technology, there are some serious concerns based on the technical aspects of the implementation. It may be that the money we are saving now with the current scheme could end up being wasted, and the other utilities that looked to Chatham-Kent for leadership might wish they hadn't. Specifically, the method of returning data from these meters to the billing system utilizes a wireless radio telemetry system, and of the many systems available, one of the most inappropriate ones was chosen.

Herein lies the cause for concern, which could help explain why the project is costing only a third of the costs faced by other utilities. This would be a fair time to assess the present implementation and consider its impact on the community in general and the ratepayers who will ultimately pick up the tab for correcting any problems caused by improperly designing a system based on a misinterpretation of Industry Canada rules.

Technical Radio Spectrum Overview

Smart Meters collect electricity usage throughout the day for each customer, and periodically transmit this data via radio back to the billing system so the customer can be charged the appropriate rate based on the time of day. This radio system requires the use of the electromagnetic frequency spectrum to function, which is a precious and congested natural resource.

Several bands of frequencies and data methods are available for this purpose, each with its own rules, advantages and disadvantages. The Ontario Energy Board listed several options, with pros and cons. In Chatham-Kent, the system has been designed to utilize the band of frequencies from 902-928 MHz, with a spread-spectrum or frequency-hopping modulation method. This is rated as a weaker choice. Technical information about this band, as provided by Industry Canada, follows.

> Industry Canada has allocated this band to Radiolocation as the Primary user, with the Amateur Radio Service being granted access as a Secondary user on the basis of causing no interference to the Primary user. As it happens, the Radiolocation services using this band are limited to shipborne radar on maritime coastal waterways. Consequently, the Secondary user is in no danger of causing prohibited interference to the Primary user in the Southern Ontario area, permitting full unrestricted Amateur use. This band is rather unusual in that, in addition to the official users, low-power licence exempt equipment is permitted as long as certain technical guidelines are followed. Typically, these radio devices use extremely low power to transmit signals very short distances of less than a hundred feet. Such unlicenced and licence-exempt equipment is permitted on a shared use, unprotected basis. That is, the frequencies have to be shared with the other users, and users are not allowed to cause interference to each other, nor to the official users of the band as allocated. All equipment must be certified by Industry Canada. Even though the regulations prohibit these devices from causing interference, licence-exempt equipment MUST accept any and all interference caused to the device, even if it results in undesirable operation. This band plan is

based on mutual respect and cooperation amongst the permitted users. It is important to note that Industry Canada DOES NOT intervene in any cases of interference amongst unlicenced and licence-exempt users.

Examples of licence-exempt equipment operating on the 902-928 MHz band are: cordless phones, crib monitors, wireless headphones, patio speakers, remote controls, wireless microphones, security systems, motion detectors, garage door openers, remote car starters, wireless computer networks – essentially any cordless electronic equipment as might be found in thousands of local homes, businesses and churches. Much of this equipment permits the user to change the channel used to prevent interference to a neighbour using the same device, as such interference would be illegal. In addition, the low power and small bandwidth required by any individual user permits a multitude of devices to co-exist, as they have in Chatham-Kent until now. Chatham-Kent Hydro monopolized the whole band so there are no free channels for anyone else.

Smart Meter RF Specifications

The Smart Meters installed by Chatham-Kent Hydro utilize an unlicenced radio transmitter operating on the 902-928 MHz band to convey data back to the billing system. Based on technical data supplied by Chatham-Kent Hydro, supplemented by further investigation, it appears that this band was chosen based on a misunderstanding of the rules governing this band. Each meter installed collects electricity usage data by the customer, and periodically sends this data back to the Chatham-Kent Hydro billing system using radio telemetry. These meters contain a small radio transmitter, in this case a TUNet module. The transmitter operates as a licence-exempt device under RSS-210 of the Radiocommunication Act. Although some of the technical information regarding these devices could not be revealed, citing patent protection, it is very easy to determine how they work by decompiling the regulations governing them.

To qualify for licence-exempt use in the 902-928 MHz band, equipment transmitter power must not exceed 50 millivolts/meter at a distance of 3 meters. This corresponds to an output power of 0.75 milliwatts, or 0.00075 watts. Since the TUNet modules transmit significantly higher power levels of 0.5 watts of RF energy, they must operate under Annex 8 of RSS-210, utilizing a spread-spectrum or frequency hopping scheme. As data is being transmitted, the transmitter frequency must "hop" through a pseudo-random sequence of channels, remaining on any individual channel for no more than 0.4 seconds. Based on the 0.5 watts power of the TUNet module, we can conclude that each unit must utilize at least 50 channels in the sequence to be legal. Since Annex 8 of RSS-210 prohibits the use of any type of synchronization, there must be significant redundant transmission of data to compensate for data lost due to collisions with other Smart Meters, noise, or interference. The system may use intelligence to avoid using a frequency occupied by a shared user of the band, but it must never be coordinated to prevent collisions with itself. The modulation of an individual frequency using 50 channels must be less than 250 kHz. The receiver is also expected to comply with the requirements of RSS-210.

Smart Meters Cause Illegal Interference

This implementation is unwise for a number of reasons.

Much consumer equipment exists in this band. Early tests indicate that most of this equipment suffers from detrimental performance in areas where Smart Meters are installed. Most of these consumers are not aware that they are receiving interference from all the Smart Meters within range of their equipment. In many cases, the interference, which causes random loud pops or clicks, renders the devices completely useless to the consumer. Chatham-Kent Hydro is aware that these devices will be negatively impacted, and states,

> *"900 MHZ telephones and baby monitors can be interfered with by the Smart Meter network. Our vendor has done testing in the area and they report that the devices ability to filter out the interference varies greatly from supplier to supplier. Some phones work perfectly fine while others report short "popping sounds" every minute or so. This interference is, although undesirable, within the realm of acceptable performance for devices operating in the 900-928 MHZ band."*

Technically, there is absolutely no way for any analog radio device to "filter out" this interference since it is co-channel interference and not a design deficiency. In other words, the undesired Smart Meter signal overpowers the desired signal on the same frequency, and there's no filter or other technology that could eliminate it. The occurrence of interference is much more frequent than once "every minute or so" as stated. **In one recent sample, over one hundred "pops" were documented in a single minute**, and this kind of intensity is observed

throughout much of the day and night. There were very few times where the intensity dropped to the level claimed by Hydro. The problem with Chatham-Kent Hydro's assurance that this is *"acceptable performance for devices operating in the 900-928 MHZ band"* is that it is ILLEGAL to cause this interference in the first place. Industry Canada requires all equipment operating under RSS-210 to cause no interference to other users, including licence-exempt users.

Hydro Justifies Smart Meter Interference

Chatham-Kent Hydro provided the following interpretation of the rules:

> *The only restrictions imposed on equipment with a secondary status using this band are:*
>
> - *The device cannot cause interference for primary users (primary users are licensed users of the 900-928 MHZ band of which there is only one known used for maritime radar (not a factor in our area)*
> - *The device must accept interference from other devices*
> - *The devices must be a low power transmitter (0-1 Watt). The TUNet modules operate at 1/2 W.*
> - *The device must meet all Industry Canada technical specifications (as is the case for the TUNet modules).*
>
> *Smart Meters operate in the 902-928 MHz frequency band, and the modules are fully certified for operation by Industry Canada and the Federal Communications Commission in the USA. i.e. the meters operate completely within regulations and are designed to coexist with any potential interferers. Because of the shareable nature of the band and the corresponding "rules" around its use, users cannot expect to have clear access, without interference from other devices."*

This interpretation is incorrect, according to Industry Canada, and could land Chatham-Kent Hydro in some expensive trouble. There is nothing about this system which is designed to "co-exist" with other users. Even though each TUNet module is Industry Canada certified, compliance with the regulations is not guaranteed. When these rules were implemented, Industry Canada and the various stakeholders which contributed input to the bandplan did not envision a mesh network of 32,000 such devices effectively monopolizing the entire band in a geographic area. The certification is for a single TUNet module, not an entire network. Further interpretation of the rules indicate that the radio receiver used by this system, which must also be certified, is to operate on a 1:1 basis; that is, one transmitter (TUNet module) must correspond with one receiver using the same 50+ channel hopset.

> **RSS-210 Annex 8.1** states, "The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals."

The assertion that *"users cannot expect to have clear access"* is incorrect, as the regulations clearly state that licence-exempt users CANNOT cause interference to each other, therefore, users CAN expect to have clear access to individual frequencies in this band. Any interpretation to the contrary is a violation of the law and the gentleman's agreement that governs shared use of this band. It appears by this statement that Chatham-Kent Hydro is knowingly causing interference and expecting everyone to roll over.

As previously stated, Industry Canada will not intervene in cases of interference, but it is still the law, enforceable in Civil Court. If an individual or business is suffering from permanent interference which renders their investment in wireless equipment useless, the law supports legal action against the offending source of interference. It is quite likely that the courts would order compensation, or could even issue an order to cease operation. Considering the many thousands of affected devices, a group of cases could be certified for Class Action.

Hydro Offers Unacceptable Solution

Chatham-Kent Hydro offered their solution to interference caused to consumer devices by Smart Meters:

> *"Thankfully, as time goes on, less and less devices will be operating in this band as most commercial products seem to be moving onto the 2.4GHZ and 5.8 GHZ bands."*
>
> (Chatham-Kent Hydro also posted instructions on their website for customers to go out and purchase new equipment that used other bands.)

This is a presumptive statement, and what it really means is that they expect their system to chase consumers entirely off the band. It makes no accommodation for the thousands of 902-928 MHz devices already in use. Forcing a migration to other bands is a poor precedent, since there is nothing to stop some other user from deciding to use those bands and chasing consumer equipment to the next band, ad infinitum.

It is important to note that this could "come back" on Chatham-Kent Hydro, as their entire system could easily be chased off this band as well. It is an unprotected allocation that has been taken rather than assigned, and that is one of the dangers of using this band. Obviously, this situation exposes some weaknesses in the regulations governing the use of all these ISM bands, weaknesses being improperly exploited by Chatham-Kent Hydro. No matter how it is analyzed, Hydro has no "rights" to monopolize this band, nor do they even have any rights to use it – its use under the strictly controlled restrictions of RSS-210 just happens to be allowed at the moment.

Industry Canada Warns of Risk

When contacted, Industry Canada was not even aware of the use of 902-928 MHz by Chatham-Kent Hydro for Smart Meters, but they are now. Under the rules, IC stated that the legality of this implementation is highly questionable, but it's worded in such a way that Industry Canada would only get involved if a licenced user is being interfered with.

However, the use of a network of 32,000 Smart Meters on this band effectively monopolizes it and prevents most other uses, which was never the intent of the bandplan, nor of RSS-210. It is highly likely that this kind of non-conforming use would be examined and banned in future bandplan updates, which could force the system to cease operation and move to a more appropriate system. Industry Canada and the Radio Advisory Board have already discussed the problem caused by Chatham-Kent Smart Meters.

Use of this band for meter telemetry required consultation with all stakeholders of the band. Nobody was consulted by Chatham-Kent Hydro, and most users are quite opposed to the ongoing implementation of these Smart Meters due to the clandestine use of 902-928 MHz without any public disclosure or consultation. Industry Canada stated that the continued use of this band by Chatham-Kent Hydro is "highly risky", since they have no protection from interference whatsoever, and have no guarantee that long-term access to this band will continue to be allowed. They added that it doesn't matter "who's there first" or who spent the most money – Chatham-Kent Hydro has "no rights" when using this band; they can use it for now on a "cause no interference basis," and will receive "no protection from interference to their system."

Chatham-Kent Hydro erroneously seems to think that they *do* have exclusive access to this band, stating, *"The [Smart Meter] device cannot cause interference for primary users (primary users are licensed users of the 900-928 MHZ band of which there is only one known used for maritime radar – not a factor in our area,"* which is wrong.

Railway Safety Compromised

There is one licenced user locally at 911.5 MHz, and that user must not suffer any interference by law. This licence is held by the Canadian Pacific Railway as part of a data handling system to ensure railway safety. A Fixed Station is a primary user of the band and the Radiocommunication Act is very clear that it is illegal for any unlicenced or licence-exempt device to cause interference, and it could also be a violation of Transport Canada rules as well. An analysis of 911.5 MHz concludes that this frequency is indeed subject to severe interference from the Smart Meter hopset, even though the bandwidth of that channel should be excluded altogether from the

hopset. If the CPR system, which runs 10 watts on that frequency as a point-to-point link, hasn't experienced any detrimental interference to date, it is highly likely that it could once 32,000 Smart Meters are installed at 0.5 watt each. This is yet another example of the improper and short-sighted implementation of 902-928 MHz equipment.

Amateur Radio Wiped Out

The 902-928 MHz is allocated in North America to the Amateur Radio Service as a secondary user. In the absence of the primary user in this region, the Amateur Radio Service has established usage of this band, and is pretty much free to use the 902-928 MHz band to the extent permitted by the terms of their licences. Chatham-Kent Hydro states:

> *"The 902-928 MHz band is also designated as an amateur band, and is also classified as a secondary user … i.e. they are second priority and must not interfere with other applications. This secondary status is allowed because in many parts of Canada (i.e. in rural regions) there are no users of these bands and there is no reason why someone like the amateur radio operators shouldn't be able to use them, as long as they don't interfere with any primary users."*

It seems as if Chatham-Kent Hydro is claiming their use of 902-928 MHz to be considered the primary one which is protected from interference from amateurs. Likewise, the assumption that use of this band is allowed by amateurs in rural regions because no one else is using it there is unfounded.

This band is in use by licenced amateurs in all regions across North America not affected by shipborne radar, and it should be stressed that Chatham-Kent Hydro is NOT protected from any interference by Amateur Radio Operators. There has been an internationally agreed bandplan for 902-928 MHz since 1997, and this band is proving ideal for operations such as FM simplex and duplex, repeaters, high-speed data, and amateur television. There are FM, IRLP, EchoLink and digital repeaters in use on this band in Southwestern Ontario, Ohio, and Michigan, with many more planned, including several in the works for Chatham-Kent.

It is worthy to note that most of the communication potential of this band would be used for Public Safety purposes as a voluntary public service, and it is ironic that Chatham-Kent Hydro, a municipal government institution, is threatening the usefulness of this band for any purpose other than their own. Amateur use of this band is expected to grow exponentially in the near future as commercially available radio equipment begins to include these frequencies.

Amateur Radio Overview

A few words about the secondary user of 902-928 MHz would be in order. Amateur Radio Operators, commonly known as "hams" are a special group of civic-minded people with an interest in radio communications. They must pass an Industry Canada examination to demonstrate proficiency in radio theory, regulations, operating procedures, electronics, and safety before being certified to operate. At the highest qualification, hams are allowed to operate on all amateur bands using up to 2250 watts PEP of power, and they are certified to build all of their own radio equipment including transmitters.

Amateur Radio Operators have built successful networks and systems for delivering non-commercial voice, data, images and television messages via radio signals. The networks include repeaters, satellites, internet links, shortwave communications, mobile and base radio stations. In times of trouble, Amateur Radio Operators are legendary for their ability to communicate when all other methods of communication fail. These selfless individuals and clubs volunteer their skills for the public good, by constantly training for emergency scenarios, and jumping into action on short notice when required. It is worthy to note that Amateur Radio Operators are often the FIRST or ONLY source of communication as demonstrated during hurricane Katrina, the Tsunami, Quebec ice storm, earthquakes, floods, power failures, and other emergencies. Most recently, NASA counted on amateur radio operators worldwide to provide backup communications to the International Space Station when a docking Russian vessel damaged an antenna.

Virtually every method of communication in use today relies on billions of dollars worth of private and public infrastructure, yet these networks are vulnerable to the likes of solar flares, satellite failure, weather, software glitches, natural and man-made disasters, or overgrown tree branches in Ohio. Amateurs do not rely on this infrastructure to communicate, and willingly serve as a back-up to it out of a passion for radio and dedication to public service – all for free. Amateur Radio Operators are not allowed to charge for their services as a condition of licence, which is why they are called Amateurs.

By using a spread spectrum signal across the entire band, interference with virtually any of the amateur uses of this band is guaranteed, yet the rules governing this band specifically prohibit unlicenced and licence-exempt users from causing such interference. There have already been documented cases where wireless licence-exempt business equipment was forced to cease operation for causing interference to the Amateur Radio Service. Granted, there is some ambivalence to the regulations concerning interference caused by amateurs, however, RSS-210 clearly states that unlicenced and licence-exempt users must not cause interference to other users , and that no protection is provided against interference from any user, including interference that causes undesired operation.

The consensus is that as the official secondary user, the Amateur Radio Service should not cause intentional interference to others, but cannot be prevented from causing unintentional interference to any user other than the primary ones.

Chatham-Kent Hydro seems to be saying that, "since we're using the entire band, nobody else is allowed to cause us interference, therefore nobody else can use it and that gives us the whole band to ourselves." There is nothing in the regulations to support this position, and it is completely contrary to the notion of "shared use." Industry Canada policy designates 902-928 MHz as a "shared" band which is usable by licence-exempt users only on a no-interference basis in the first place, and a spread spectrum signal from 32,000 Smart Meters clearly precludes the possibility of sharing the band with anyone.

Amateur Radio Operators are generally a reasonable, public-service oriented group. However, many of their operating privileges come from years of personal effort, and the existing ham radio frequency allocations are the result of years of intense lobbying on a world-wide basis. The Smart Meter situation has gained the notice of amateurs across the country, and the RAC (Radio Amateurs of Canada) is following this case with a vested interest, as is Industry Canada, now that they are aware. It is highly likely that there will now be a coordinated effort amongst concerned users of this band to lobby for changes which prevent the type of use currently implemented by Chatham-Kent Hydro on 902-928 MHz due to the negative impact of spread spectrum on so many other users.

Official Bandplan for 902-928 MHz

The Canadian bandplan adopted in 1997 is as follows:

902-928 MHz

Available spectrum 26 MHz

FIXED and RADIOLOCATION PRIMARY

Amateur and Land Mobile secondary

902.0 – 902.5 PACKET (<=2400 B, 25 kHz CH)

902.5 – 902.8 TTY, PACKET (<= 2400 B, < =2.5 kHz BW)

902.8 – 902.9 PACKET (<= 2.5 kHz BW), TTY, CW, EME (Earth-Moon-Earth)

902.9 – 903.1 CW; EME

903.100 NATIONAL CW/SSB DX CALLING FREQUENCY

903.1 – 903.2 CW, SSB, EME

903.200 NATIONAL SSB CALLING FREQUENCY (LOCAL)

903.2 – 903.3 SSB, SSTV, FAX, PACKET (BW < =2.5 kHz) AM, AMTOR

903.3 – 903.32 PROPAGATION BEACON NETWORK

903.32 – 903.4 GENERAL PROPAGATION BEACONS

903.4 – 903.5 SSB, SSTV, ACSSB, FAX, PACKET (BW <= 2.5 kHz) AM, AMTOR, EXPERIMENTAL (BW <= 2.5 kHz)

903.5 – 903.7 CROSSBAND LINEAR TRANSLATOR INPUTS

903.7 – 903.9 CROSSBAND LINEAR TRANSLATOR OUTPUTS

903.9 – 904.0 EXPERIMENTAL BEACONS

904.0 – 904.3 CONTROL AND AUXILIARY LINKS

904.3 – 904.5 FM SIMPLEX (25 kHz CHANNELING)

904.500 NATIONAL FM CALLING FREQUENCY

904.5 – 905.0 FM SIMPLEX (25 kHz CHANNELING)

905.0 – 907.0 HIGH RATE DATA (>=4800 B, DUPLEX)

907.0 – 910.0 FM REPEATER INPUTS (25 kHz CHANNELING)

910.0 – 916.0 FAST SCAN TV (SIMPLEX OR REPEATER OUTPUT, PAIRED WITH 922.0 928.0 AND 439.0 444.0 MHz)

916.0 – 916.5 PACKET (<= 2400 B, 25 kHz CHANNELING)

916.5 – 919.0 HIGH RATE DATA (>=4800 B , DUPLEX)

919.0 – 922.0 FM REPEATER OUTPUTS (25 kHz CHANNELING)

922.0 – 928.0 FAST SCAN TV SIMPLEX OR REPEATER INPUT, SPREAD SPECTRUM, EXPERIMENTAL MODES

Planned Local Uses of 902-928 MHz by Amateur Radio

There are several projects already underway in Chatham-Kent which could cause problems with the Smart Meter telemetry. A wide-area radio link is under development which will provide FM voice communications across the municipality. This will include several repeaters with remotes which are connected together, and also linked to similar systems across the world using the internet. High-speed data links are also planned that will provide wireless internet access during emergencies. Also, a television repeater is being developed for Chatham to facilitate the transmission of video between communities.

These uses will be properly licenced and coordinated. The system is designed to avoid the frequency used by the CPR, and any interference to consumer equipment could be easily tuned out by the user. It is probable that, through normal legal use, Amateur operations could unintentionally affect the Smart Meter data to the point where the entire system is unreliable.

Had the Amateur Radio Community been consulted by Hydro prior to spending millions of dollars on Smart Meters, Hydro would have been aware of pending uses of this band.

Ontario Energy Board Recommendations Ignored

The Ontario Energy Board has published “Smart Meter Implementation Plan” to assist in the province-wide adoption of Smart Meters by 2010. One of the considerations examined was the method of transferring data from individual Smart Meters to the Utility billing system. Among the systems examined were telephone, PCS, 200 MHz radio, 400 MHz radio, 1400 MHz radio, and 902-928 MHz spread spectrum. In rural areas, telephone connections were considered as the only viable option, but some forms of radio telemetry were deemed feasible in suburban and urban areas.

The OEB recognized that 902-928 MHz is allocated as a low-power licence-exempt public band, and was an option only if the population resided in a 500-700 foot radius. **These guidelines recommended a propagation study** to determine the level of activity from other users. It would appear that **no such study ever took place in Chatham-Kent,** and if it did it was deeply flawed, since it even failed to identify the existing licenced station used by the CPR, and consultations with the official secondary user of the band did not occur. In Freedom of Information requests, Chatham-Kent Hydro said the required study didn’t exist, but upon further digging it seems a study would be made available on payment of $950.

Chatham-Kent Hydro neglected to consult with the Amateur Radio community, which could have easily alerted Hydro to existing and proposed uses of the 902-928 MHz band. Further, there were no public consultations with the many citizens who own licence-exempt wireless devices operating on these frequencies. Indeed, many people may not even be aware what frequency their devices work on, or even that they use radio signals at all. The average consumer would rely on the honest disclosure by Chatham-Kent Hydro that the Smart Meter program might impact their devices in a noticeable way and render them useless.

Instead, we see evidence that the exact nature of this system has been withheld from the public, with the focus being placed instead on Press Releases hyping the award winning role of Chatham-Kent Hydro in Ontario’s Smart Meter program, and the huge cost savings realized. Ratepayers are left to wonder why their equipment no longer works properly, likely never linking the cause to the Smart Meters installed on their house and in their neighbourhood. Perhaps it’s becoming clear why the implementation cost was so much lower than OEB estimates. I also learned that it’s common for suppliers to nominate a client – the municipality – for these awards in the first place.

There was a much better option than 902-928 MHz. The OEB identified the 1400 MHz band as being feasible for suburban and urban use. Some R&D was still required on this band, but it was considered an excellent option if it didn’t run contrary to other allocations on that band. As it happens, in Chatham-Kent there are no users on this band.

Industry Canada recognizes the need for protected Automatic Meter Reading (AMR) spectrum, and recently invited comments on proposed changes to spectrum in frequencies below 1.7 GHz (DGTP-004-05). The bandplan restructuring that resulted **created an allocation** on this band for Smart Meter (AMR) telemetry, from 1429.5-1432 MHz. An added advantage to these frequencies is exclusive use , which is also aligned with the FCC in the United States. As a result, this North American allocation greatly enhances the availability of suitable equipment.

These frequencies require a licence, which offers long-term stability and official protection from interference. A licence provides other benefits as well, including the use of higher transmitting power and more efficient modulation techniques, like packet (since data would not have to be transmitted several times redundantly to account for interference and co-channel occupancy). **This encourages the responsible and efficient use of valuable radio spectrum, instead of the wasteful method currently employed** . Higher power radio signals could overcome local propagation difficulties, and eliminate the need for many of the 220 MHz data repeaters which would be needed with the 902-928 MHz system. RSS-142 details the specifications of the standards. This is an area where Chatham-Kent Hydro could have really proven itself a leader in the industry, but failed.

Chatham-Kent Hydro Supported the Loss of 220-222 MHz Band to Amateurs

Some interesting observations can be made referring to Industry Canada's **Gazatte Notice No. DGTP-004-05 – Proposals and Changes to the Spectrum in Certain Bands Below 1.7 GHz** . In a letter to Industry Canada dated January 20, 2006, Chatham-Kent Hydro stated the need for frequency spectrum allocated to automatic meter reading and power outage notification. They applauded the initiative to allocate the 220-222 MHz band for this purpose and voiced strong support, citing its suitability for their communication solutions. No mention was made of 902-928 MHz which was already being implemented by Chatham-Kent Hydro at the time (unbeknownst to Industry Canada), nor of 1400 MHz which was being allocated specifically for this purpose. As a direct result of interventions like this, the frequency range of 220-222 MHz was lost from the Amateur Radio Service. Identical letters from the Ottawa River Power Corporation and Waterloo North Hydro Inc. suggest a bit of form-letter lobbying going on. Hydro seems intent to support the removal of as much spectrum from the Amateur Radio Service as they can get away with.

The discussion in Section 8.2 of DGTP-004-05 should have been of greater interest since it specifically refers to AMR allocations and the new sub-band created from 1429.5-1432 MHz to permit primary protected use of AMR. In reality, the Ontario Energy Board identified the 220-222 MHz band as being mostly unsuitable for AMR purposes. The discussions in DGTP-004-05 suggest that the licence-exempt 902-928 MHz band might accommodate AMR using an expected 1 MHz bandwidth, but most effort went towards creating a sub-band solely for utility AMR.

The 220-222 MHz band is claimed to be in use by Chatham-Kent Hydro to transmit all the data collected from the 902-928 MHz spread spectrum sources back to the central office billing computers. It is pertinent that all the data from the 26 MHz bandwidth used by the meters can be easily compressed into the 2 licenced frequencies in the 220-222 MHz band [220.9725 and 221.9725 MHz] with only 3.2 kHz bandwidth (0.0032 MHz), effectively proving the wasteful and inefficient use of the 902-928 MHz band.

Updates in 2010

When Chatham-Kent Hydro ignored the writer's concerns, the media was contacted and given a full overview of the problem. The phone lines at Chatham-Kent Hydro were immediately overloaded by people with interference complaints, now that they knew the source. Embarrassed hydro officials were summoned before Chatham-Kent council, where they gave a glowing report that was seriously misleading, and promised to help customers experiencing interference.

In private, Chatham-Kent hydro told the writer that they had seriously underestimated the interference the meters would cause, but this is not what council was told. They admitted nobody on staff had any experience with radio systems, and could not notch out the interference. Hydro then proceeded to issue press releases promoting their Smart Meter progress, including photo ops with the mayor, and winning an industry award.

In response to the interference complaints, Chatham-Kent Hydro was forced to a page on their website that said in part:

> With respect to recent newspaper articles highlighting potential interference issues caused by our new Smart Meter network, Chatham-Kent Hydro is working actively with our vendor to resolve these issues on a case-by-case basis. As there are many sources of interference on 900MHz devices, you can identify the Smart Meter signal as a rapid clicking sound. Although conversation is possible, it is difficult and annoying.

In other words, Hydro wasn't too happy being exposed in the media. That web page has disappeared, while 900 MHz devices are still being sold, and customers still can't use them.

In retaliation for those "newspaper articles" and council grilling, Chatham-Kent Hydro arbitrarily demanded that the writer pay a deposit under threat of disconnection, to the maximum

amount their policy allowed. Several months later, they demanded another deposit, and were able to cite *new* rules allowing them to force the payment of a higher amount.

It gets better. When the president of Chatham-Kent Hydro retired, he had himself appointed to the committee that administered the writer's employment. Within days, I experienced sabotage and interference with my employment.

The mayor of Chatham-Kent sits on the Chatham-Kent Hydro board. His office was also involved in a smear campaign against the writer which involved private municipal information showing up in the wild to damage my reputation and credibility in the community. Chatham-Kent Hydro was really not happy about this research. Plenty was done to retaliate, but not one single point was challenged. Authorities are currently investigating the unauthorized release of my private hydro account information that included defamatory comments about my family.

While Chatham-Kent Hydro officials were deposing to council about how inexpensive their smart meter implementation had been, they were preparing OEB applications to hike the smart meter cost recovery by 200%.

Security of Mesh Network

Most Smart Meter companies promote the security of their system. This feature is conspicuously absent from the TuNet technical specifications. While there may be some form of encryption, perhaps they used a cheap off-the-shelf chipset and relied on security by obscurity. Tantulus states their Smart Meters will interface easily with other smart devices using a data format that's compatible with other manufacturers' products.

It's likely only a matter of time before somebody is able to hack into the system and monitor or alter traffic. There are plenty of nefarious reasons why people might want access to billing data.

Conclusion

In conclusion, many factors as listed below have demonstrated why the Chatham-Kent Hydro Smart Meter implementation is seriously flawed. For only 3 cents per customer per year, Chatham-Kent Hydro could have used licenced and protected Smart Meters that eliminated all of these problems.

- **Chatham-Kent Hydro defied Ontario Energy Board guidelines requiring a propagation study and consultation with local users of 902-928 MHz**
- **Unlicenced and licence-exempt users are strictly prohibited from causing interference to any other users, including other unlicenced users**
- **Hydro has no rights to use the 902-928 MHz band beyond the temporary ability to use the band on a non-interfering licence-exempt basis**
- **Hydro's use of this band prevents clear access to the band for every other user**
- **Industry Canada does not sanction the wasteful use of the entire 902-928 MHz band for this purpose, and warns of the serious financial risk of investing in unlicenced systems**
- **Interference is caused to a licenced user, a Canadian Pacific Railway safety system**
- **Amateur Radio is denied the legitimate use of the entire band by telemetry interference**

- **Communication systems are being installed locally that could cause the Smart Meter telemetry to fail**
- **Other users could be licenced to use this band by Industry Canada without regard to existing unlicenced use by Hydro**
- **In the United States, the Amateur Radio Service is the Primary user; the same status is being sought in Canada**
- **Residents and businesses are prevented from the peaceful enjoyment of their wireless electronic devices**
- **Hydro's attitude that existing users will just "move off" the band while claiming protection from interference to Smart Meter telemetry is high-handed and unsupported by the regulations**
- **Hydro has no enforceable protection against any form of interference, even if it causes the entire system to fail**
- **Smart Meter telemetry has no legal status on this band and could be forced by IC to cease operation at any time**
- **Using a 26 MHz wide bandwidth to transmit data that can be accommodated in a 1 MHz bandwidth is wasteful and irresponsible pollution of the electromagnetic spectrum which violates the responsibility use the minimum bandwidth required to maintain communications**
- **Spending $4.6 million of ratepayer funds to build a telemetry system with no legal status nor long-term viability while serving it as a model for other utility companies to emulate could be considered a serious miscalculation and foolish**
- **The system may not be all that secure. An open mesh network designed for easy cross-platform data integration could be subject to attack.**
- **When time-of-use billing kicks in, every Chatham-Kent Hydro bill will increase, even if people do all their living at night. Our bills are now substantially higher, despite conserving religiously and contrary to assurances by Hydro officials when the plan was rolled out. Windsor and Essex have currently deferred time-of-use billing due to the negative impact.**

The present use of Smart Meters on the 902-928 MHz band is unsanctioned by Industry Canada, which has already warned that there is no long-term life to this system. It should have been stopped right away and switched to a licenced system with predictable long-term viability before further ratepayer money was wasted. One user simply cannot wantonly monopolize the entire band without regard for other legitimate users.

It is unfortunate that a substantial amount of ratepayer money has been spent on this project already.

Report prepared by:

Austin Wright

Resources:

Industry Canada (IC)

Ontario Energy Board (OEB)

Radio Amateurs of Canada (RAC)

American Radio Relay League (ARRL)

Chatham-Kent Amateur Radio Club

Chatham-Kent Energy

Municipality of Chatham-Kent

Radio Advisory Board of Canada

Tantulus

HF35C RF Analyzer at 258 Heyburn Rd, Chadds Ford, PA, 4/16/16. Background RF 0.0-0.1uW/m2

	Video Time Stamp	short pulse 35-50uW/m2	long pulse 35-50uW/m2	>200 uW/m2		
	0:00:04		X			
	0:00:12	X				
	0:00:27	X				
	0:00:42	X				
	0:00:57	X				
	0:01:12	X				
	0:01:27	X				
	0:01:42	X				
	0:01:56	X				
	0:02:12	X				
	0:02:27	X				
	0:02:42	X				
	0:02:50	X				
	0:02:57	X				
	0:03:04	X				
	0:03:11	X				
	0:03:12	X				
	0:03:16	X				
	0:03:26	X				
	0:03:41	X				
	0:03:56	X				
	0:04:00	X				
	0:04:11	X				
	0:04:26	X				
	0:04:29			X (10 sec)		
	0:04:41	X				
	0:04:56	X				
	0:05:10	X				
	0:05:26	X				
	0:05:41	X				
	0:05:56	X				
	0:06:11	X				
	0:06:26	X				
	0:06:41	X				
	0:06:56	X				
	0:07:11	X				
	0:07:26	X				
	0:07:41	X				

	0:07:56	X				
	0:08:11	X				
	0:08:26	X				
	0:08:40	X				
	0:08:55	X				
	0:09:03	X				
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	0:18:33	X				
	0:18:39	X				
	0:18:46	X				
	0:18:53	X				
	0:18:55	X				
	0:19:10	X				
	0:19:25	X				
	0:19:40	X				
	0:19:55	X				
	0:20:05		X			
	0:20:10	X				
	0:20:25	X				
	0:20:40	X				
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	0:21:10	X				
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	0:31:39	X				
	0:31:54	X				
	0:32:09	X				
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	0:32:39	X				
	0:32:54			X (10 sec)		
	0:33:09	X				
	0:33:24	X				
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	0:33:56	X				
	0:34:02	X				
	0:34:09		X X			
	0:34:15	X				
	0:34:22	X				
	0:34:24	X				

Baubiologische Richtwerte

(AC) für Schlafbereiche gemäß SBM-2015*

		Auffälligkeit	keine	schwache	starke	extreme
Hoch-frequenz	HF	µW/m² (Peak)	< 0,1	0,1 - 10	10-1000	> 1000
Niederfrequenz	M	nT	< 20	20 - 100	100-500	> 500
Niederfrequenz	E	mit Erdkabel V/m	< 1	1 - 5	5 - 50	> 50
		potentialfrei V/m	< 0,3	0,3 - 1,5	1,5 - 10	> 10

Mehr Info: www.baubiologie.de/downloads/richtwerte-schlafbereiche-15.pdf *© IBN/Maes

Building Biology Evaluation Guidelines

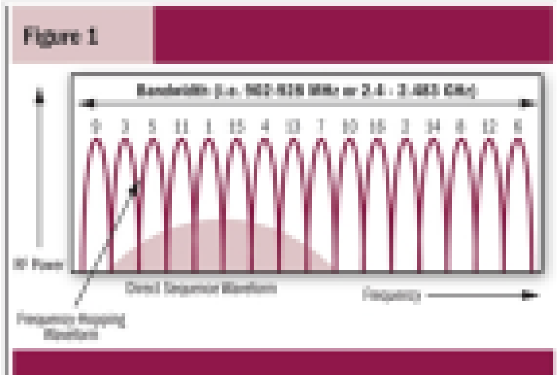
(AC) for Sleeping Areas (SBM-2015)*

		Anomaly	No	Slight	Severe	Extreme
High Frequency	HF	µW/m² (Peak)	< 0.1	0,1 - 10	10-1000	> 1000
Low Frequency	M	nT	< 20	20 - 100	100-500	> 500
Low Frequency	E	with grounding cable V/m	< 1	1 - 5	5 - 50	> 50
		potential-free V/m	< 0.3	0.3 - 1.5	1.5 - 10	> 10

Further Information: www.buildingbiology.com/about-the-institute *© IBN/Maes

AMI Radios Characteristics

- Frequency Hopping Radio Signals
  - "Spread Spectrum" is a frequency hopping technique invented by the famous 1940's actress "Hedy Lamar" and sends "packets" of information. It was developed to foil the enemy radio signals from blocking our proximity sensing anti-aircraft shells in WWII.
    - Frequency Hopping is a technique to avoid collisions of transmitted signals, so the first packet of data will be sent to a random channel in the frequency range. If it senses that there was a collision it shifts the frequency until it is successful in sending the data packet, then the process starts all over again for the next packet. Packet size can vary from 576 bytes to 1500 bytes, ITRON does not disclose the packet size it uses. As the number of meters increase the signal experiences a lot of collisions causing retransmissions
    - The number of transmissions increases as the number of nodes in the network increases, the result is a type of radio immersion of the entire neighborhood, sometimes called a "Radio Soup" environment leaving no safe harbor from the microwave radiation.
    - Packets are sent approximately every 4-5 seconds all day based on observations of readings. The daily upload of the meter data usually occurs each night taking from one to two hours long.



ORIGINAL

0000178630

Erik S. Anderson, P.E.
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eanderson@aenpi.com

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BEFORE THE ARIZONA CORPORATION COMMISSION

Arizona Corporation Commission
DOCKETED

APR 3 2017

DOCKETED BY GB

COMMISSIONERS
TOM FORESE, CHAIRMAN
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DOUG LITTLE
ANDY TOBIN

ANDERSON DEPOSITION EXHIBIT 6

IN THE MATTER OF THE APPLICATION OF ARIZONA PUBLIC SERVICE COMPANY FOR A HEARING TO DETERMINE THE FAIR VALUE OF THE UTILITY PROPERTY OF THE COMPANY FOR RATEMAKING PURPOSES, TO FIX A JUST AND REASONABLE RATE OF RETURN THEREON, TO APPROVE RATE SCHEDULES DESIGNED TO DEVELOP SUCH RETURN.	**DOCKET # E-01345A-16-0036** **DIRECT TESTIMONY OF ERIK S. ANDERSON, P.E. ON BEHALF OF WARREN WOODWARD AND IN OPPOSITION TO THE SETTLEMENT AGREEMENT**
IN THE MATTER OF FUEL AND PURCHASED POWER PROCUREMENT AUDITS FOR ARIZONA PUBLIC SERVICE COMPANY	**DOCKET # E-01345A-16-0123**

Erik S. Anderson, P.E., Witness in the above-referenced proceeding on behalf of Intervenor Warren Woodward, hereby submits his Direct Testimony.

TABLE OF CONTENTS

I. INTRODUCTION

Q: Please state your name, address, and occupation.

A: Erik S. Anderson, P.E., 3725 E. Roeser Road, Suite 20, Phoenix, Arizona 85040. I am a forensic electrical engineer working on root cause failure analysis of matters that cause loss of property, personal injury, and loss of life. I am the President of an engineering firm that offers professional engineering services across the United States and that manufactures current transformers.

Q: What is your professional and educational background?

A: I have a Bachelor of Science degree from North Dakota State University, Fargo, North Dakota, in Electrical and Electronic Engineering. I am a licensed Professional Engineer in the states of Minnesota, Illinois, Arizona, Wisconsin, Indiana, Iowa, New Mexico, Texas, Louisiana, California, Kentucky, Michigan, and Nevada. I am a licensed Class A Master Electrician in the state of Minnesota. I hold a Private Investigators License in Arizona and I am a Certified Fire and Explosion Investigator. I have 30 years of experience as a forensic engineer. I have over 20 years of experience of design and manufacture of current transformers. I have been involved in many thousands of matters concerned with determining the root cause of failures of electrical devices that may have caused a loss of property, personal injury, or loss of life. I have given expert witness testimony in approximately 113 separate matters. [Attached hereto as Exhibit "D" is a copy of my current curriculum vitae.]

Q: What is the purpose of your direct testimony in these proceedings?

A: My direct testimony in these proceedings is regarding the effect the Smart Meter has on the 60 Hz waveform of the electrical power as delivered by the utility. My direct testimony will be that the Smart Meter causes a significant amount of noise on the 60 Hz signal.

Q: Have you testified previously before the Commission?

A: No.

II. SUMMARY OF DIRECT TESTIMONY

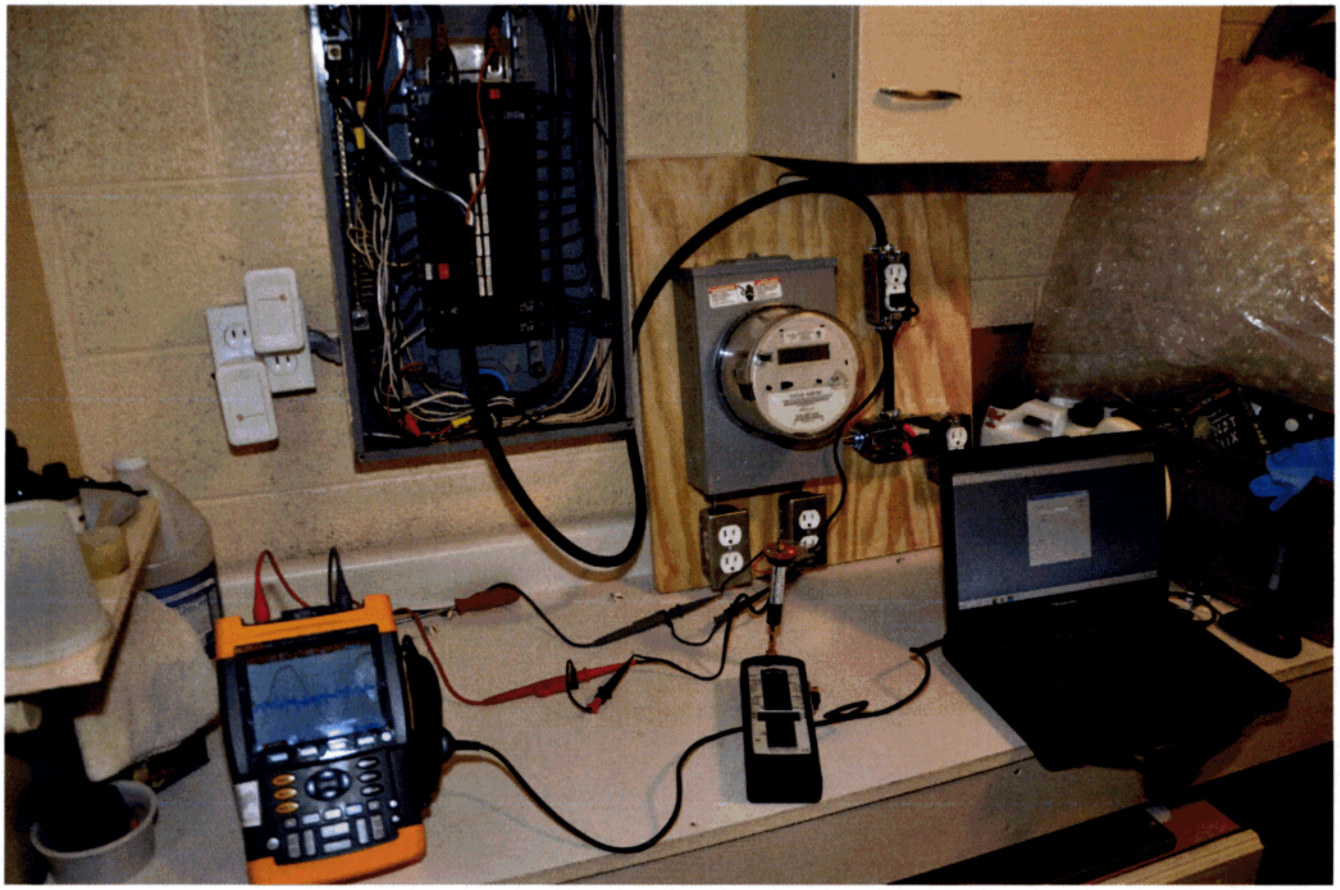
Q: Please summarize your direct testimony.

A: I have witnessed and analyzed the effects of the use of a Smart Meter on the incoming electrical power voltage waveform. The Smart Meter, when transmitting data, causes a significant amount of noise on the incoming electrical power. Power is delivered at 60 Hz. The Smart Meter causes much higher frequencies to be imposed on the 60 Hz sinusoidal wave. When the Smart Meter transmits information, there is a significant increase of the noise observed on the 60 Hz sinusoidal waveform. There were significant increases in the noise in the range of 2 to 50 kHz, or 2,000 to 50,000 cycles per second.

III. DIRECT TESTIMONY

Q: Please describe the test setup of the incoming electrical power.

A: The test setup consists of a meter socket enclosure suitable for 120/240 Volt, single-phase, three-wire connection. A Smart Meter, Landis & Gyr, Gridstream RF, Focus AXR-SD, Form 2S, CL200, 240 V, 3 W, 60 Hz, power meter was used. The voltage waveform was captured with a Fluke 215C Scopemeter. One input to the Scope meter was connected to the incoming voltage, 120 Volts-to-Ground, unfiltered. The other input to the Scope meter was connected to the incoming voltage with the 60 Hz Sine wave filtered out. A radio frequency (RF) meter was also used to indicate when an RF signal increase was detected.



Q: Please describe the observations you made during the testing of the Smart Meter.

A: When the test equipment was connected to the incoming power the waveform of the incoming electrical power was observed. The 60 Hz signal was recognized as the dominant frequency with some noise observed on the waveform. The 60 Hz was filtered out to analyze the noise on the signal. Without the Smart Meter attached, the noise level was approximately 45 milliVolts at its peak. When the Smart Meter was added to the circuit and the noise on the 60 Hz Sine wave was noticeably larger. The peak noise voltage, with the Smart Meter attached was approximately 85 milliVolts. The amount of noise, with the Smart Meter attached to the circuit was approximately twice as large than without the Smart Meter.

Q: Can you show us examples of the waveforms?

A: Yes. Exhibit A is a screenshot of the waveform without a smart meter in the circuit. Exhibit A shows the 60 Hz waveform in red. The noise waveform, after filtering out the 60 Hz, is shown in blue. When the Smart Meter is installed in the circuit, and it is transmitting, the waveforms look like that in Exhibit B. Exhibit B shows the noisy, dirty, waveform of the 60 Hz signal in red. The noise waveform is shown in blue.

Q: What are the frequencies observed on the noise (blue) waveform, of Exhibit B?

A: The dominant frequencies found on the waveform of the noise (blue) waveform of Exhibit B are approximately in the range of 2 to 50 kHz. These are the

frequencies that the Smart Meter generates when it is transmitting

Q: Can you provide a sampling of those frequencies?

A: Yes, Exhibit C showcases waveforms found to represent 12.5 kHz, 14.28 kHz, 16.6 kHz, 20 kHz, and 33.3 kHz. The point between the two cursors represents these frequencies.

IV. CONCLUSION

Q: DO YOU HAVE ANY CONCLUDING REMARKS?

A: Yes. The Smart Meter tested exhibited a significant amount of noise generation on the incoming electrical power to the residence.

RESPECTFULLY SUBMITTED this 3rd day of April, 2017.

By: /s/ Erik S. Anderson
Erik S. Anderson, P.E., C.F.E.I.
3725 East Roeser Road, Suite 20
Phoenix, AZ 85040

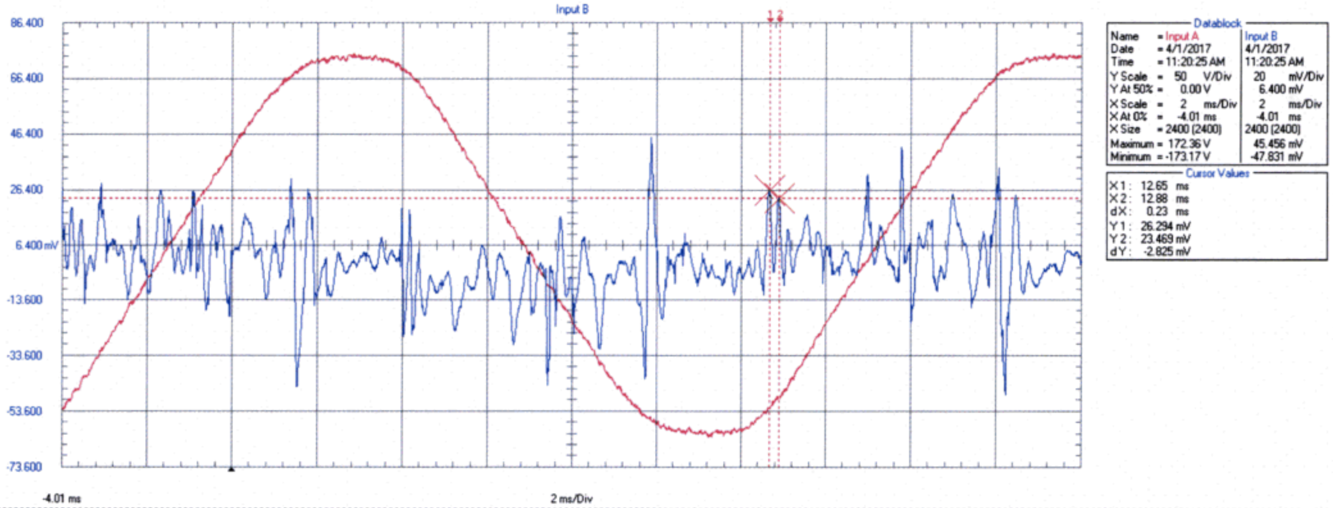
Original and 13 copies of the
foregoing hand-delivered
this 3rd day of April, 2017 to: Arizona Corporation Commission, Attn: Docket Control Center, 1200 W. Washington, Phoenix, AZ 85007

Copies of the foregoing
mailed/e-mailed this 3rd
day of April, 2017 to: Docket Service List

By,

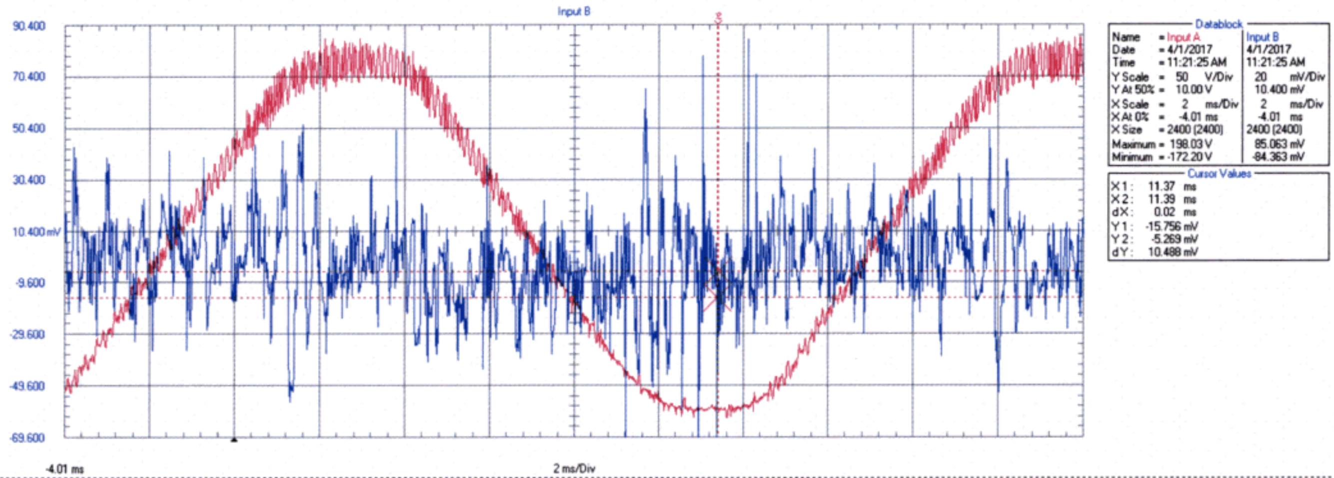
Warren Woodward
200 Sierra Rd.
Sedona, AZ 86336

Exhibit "A"



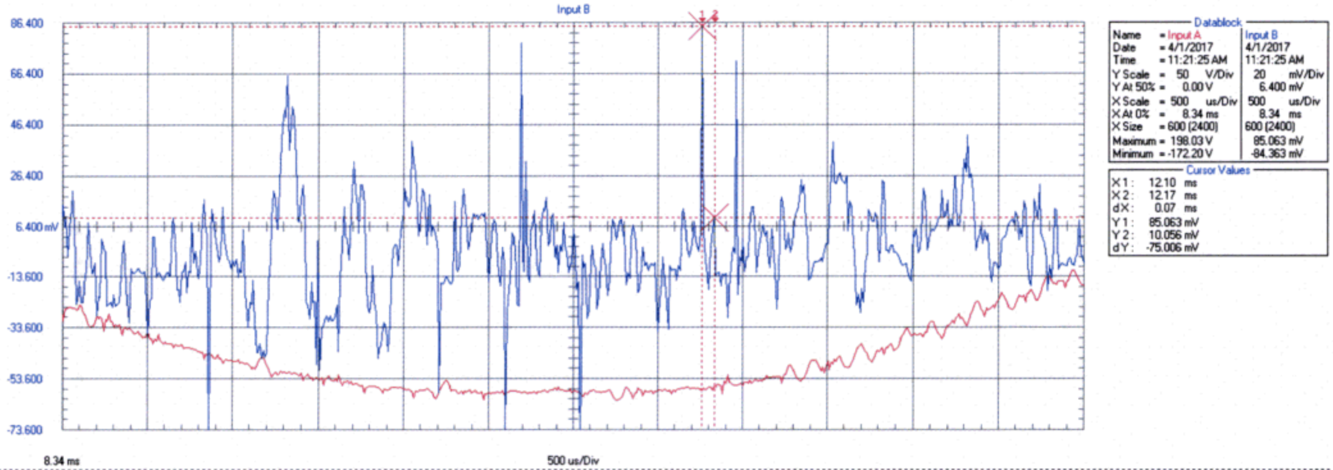
The waveforms were collected without a smart meter using a Fluke 215C Scopemeter. Channel A was connected to a 120 VAC receptacle. Channel B was attached to the same potential except through a Graham Ubiquitous filter (removes the 60 cycle).

Exhibit "B"

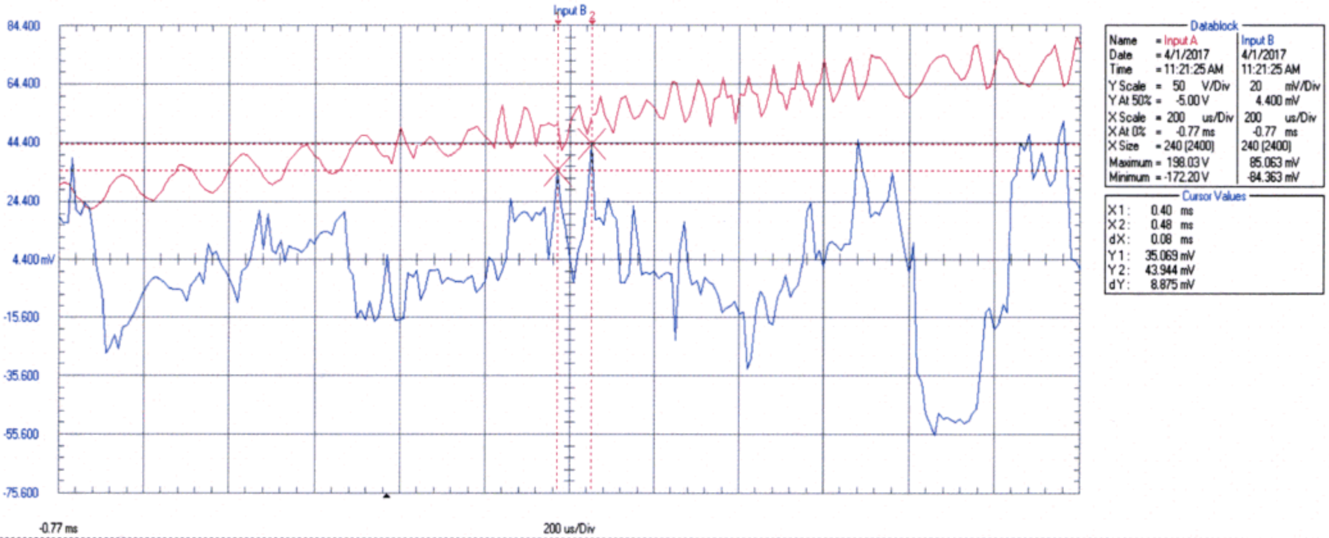


The waveforms were collected from a transmitting smart meter using a Fluke 215C Scopemeter. Channel A was connected to a 120VAC receptacle. Channel B was connected to the same potential except through a Graham Ubiquitous filter (removes the 60 cycle). The point between the two cursors represents a frequency of 50 kilo Hertz.

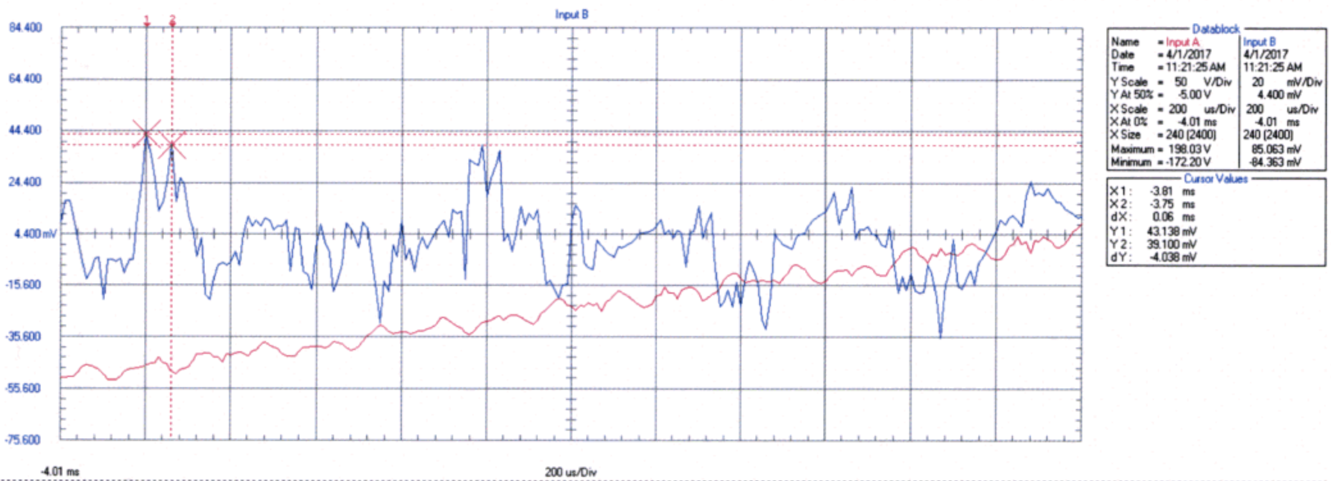
Exhibit "C"



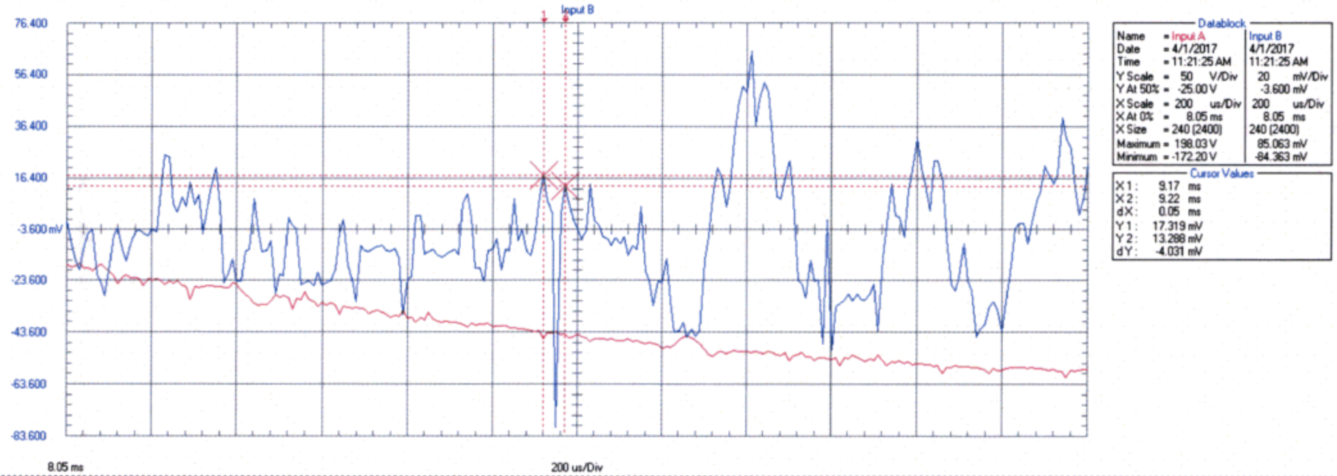
The waveforms were collected from a transmitting smart meter using a Fluke 215C Scopemeter. Channel A was connected to a 120VAC receptacle. Channel B was connected to the same potential except through a Graham Ubiquitous filter (removes the 60 cycle). The point between the two cursors represents a frequency of 14.28 kilo Hertz.



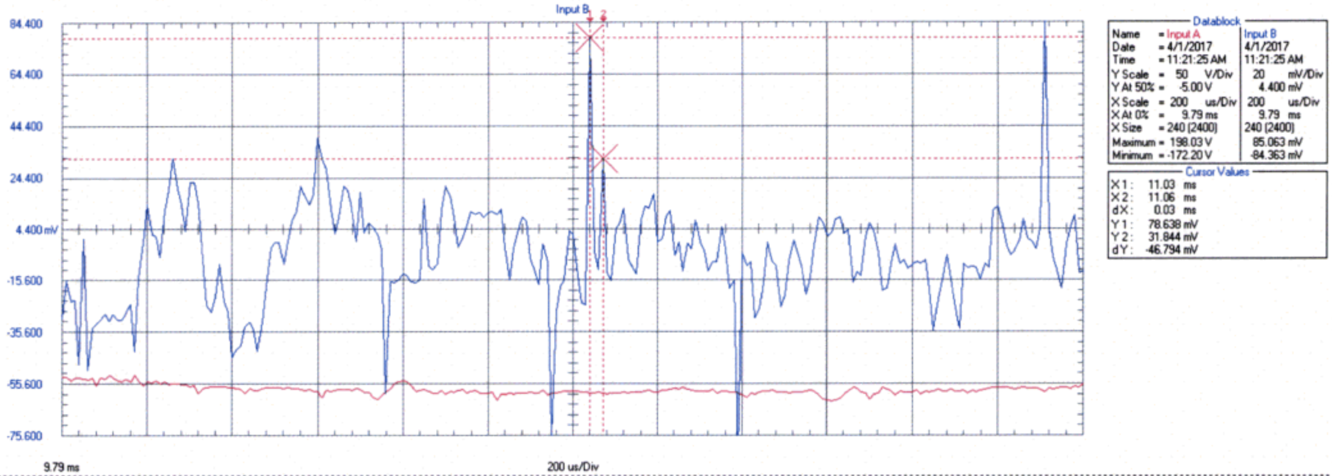
The waveforms were collected from a transmitting smart meter using a Fluke 215C Scopemeter. Channel A was connected to a 120VAC receptacle. Channel B was connected to the same potential except through a Graham Ubiquitous filter (removes the 60 cycle). The point between the two cursors represents a frequency of 12.5 kilo Hertz.



The waveforms were collected from a transmitting smart meter using a Fluke 215C Scopemeter. Channel A was connected to a 120VAC receptacle. Channel B was connected to the same potential except through a Graham Ubiquitous filter (removes the 60 cycle). The point between the two cursors represents a frequency of 16.6 kilo Hertz.



The waveforms were collected from a transmitting smart meter using a Fluke 215C Scopemeter. Channel A was connected to a 120VAC receptacle. Channel B was connected to the same potential except through a Graham Ubiquitous filter (removes the 60 cycle). The point between the two cursors represents a frequency of 20 kilo Hertz.



The waveforms were collected from a transmitting smart meter using a Fluke 215C Scopemeter. Channel A was connected to a 120VAC receptacle. Channel B was connected to the same potential except through a Graham Ubiquitous filter (removes the 60 cycle). The point between the two cursors represents a frequency of 33.3 kilo Hertz.

Exhibit "D"

ANDERSON ENGINEERING OF NEW PRAGUE, INC.

3725 E. Roeser Road, Ste. 20
Phoenix, Arizona 85040
Phone: (602) 437-5455
Fax: (602) 437-3272

ERIK S. ANDERSON

Registered Professional Engineer

REGISTRATION:	**Licensed Professional Engineer**		
	State of Minnesota	1991	21471
	State of Illinois	1999	062052733
	State of Arizona	2003	39627
	State of Wisconsin	2008	39418-006
	State of Indiana	2008	PE.10809314
	State of Iowa	2008	18758
	State of New Mexico	2008	19001
	State of Texas	2009	102714
	State of Louisiana	2009	PE.0034787
	State of California	2010	105359
	State of Kentucky	2012	28492
	State of Michigan	2013	6201060247
	State of Nevada	2013	022690
	Other Licenses:		
	Licensed Class A Master Electrician – State of Minnesota	1995	AM005344
	Private Investigator – Arizona	2011	1615601
	Certified Fire and Explosion Investigator (C.F.E.I.)	2012	17853-9760

EDUCATION: B.S. in Electrical and Electronic Engineering
North Dakota State University, Fargo, North Dakota, 1987.

Chemical Engineering Course Work
University of Minnesota, Minneapolis, Minnesota, 1981-1983.

CONTINUING Hazardous Materials: HAZWOPER: 40-hour worker 2008

EDUCATION:

Annual 8-Hr. HAZWOPER Refresher Course: 2009, 2010, 2011, 2012, 2013, 2014, 2015,

Asbestos Awareness: 05/09, 3/14, 09/16

Annual Fire Investigation Seminar Instructor
Maricopa AZ: 04/08, 03/09, 03/12, 03/13

Minnesota Chapter IAAI Fire & Arson Conference
3/88, 3/89, 3/90, 3/01, 3/05, 3/06.

Instructor: Fire/Arson Level 3
Mesa, Arizona, 10/03.

Illinois Chapter IAAI Northern Zone Winter Seminar
Instructor: Electrical Appliance Fires, 2/03.

Completed Code & Code Change Class
Minnesota Electrical Association – National Electrical Code
1/99, 2/01, 1/03, 1/05, 1/07, 1/09, 1/11, 2/13, 5/15

Illinois Chapter IAAI Fire Investigation Conference
Instructor: Forensic Electrical Engineering Principles & Practices, 9/99.

Graduate Course Work, University of Minnesota
Minneapolis, Minnesota, 1995-1997.

Master Electrician Course, Hennepin County Technical College, Eden Prairie, Minnesota 3/95.

Completed Designing Electrical Systems for Hazardous Locations
University of Wisconsin-Madison, 4/92.

Completed Electrical Fires Accidental and Deliberate
Sponsored by Georgia Chapter of IAAI, 12/91.

Completed Fire and Arson Investigation Course,
Nebraska State Fire & Arson Investigators Conference, 10/87

EXPERIENCE:

01/05 - Present

Anderson Engineering of New Prague, Inc., *Phoenix, AZ*
President & Forensic Electrical Engineer. Responsible for all aspects of business operations including engineering services to clients, product testing, fire investigation, and failure analysis.

Our case load also includes construction defect cases involving the evaluation of the workmanship of the electrical subcontractor and personal injury cases involving electric shock and/or electrocutions.

4/87 – 1/05	Anderson Engineering of New Prague, Inc., *New Prague, MN* Electrical Engineer. Responsible to client for engineering services including product testing, fire investigation, and failure analysis. Midwest Current Transformer, Division of Anderson Engineering of New Prague, Inc., *New Prague, MN.* Designer, manufacturer, and quality control engineer of current transformers.
1/84 - 11/84	O.S. Anderson Engineering, Inc., *New Prague, MN.* Research and Design Coordinator. Duties included work on transponder design for communications system through earth.
6/83 - 9/83	Koch Refinery, *Southeast St. Paul, MN.* Conducted ultrasound testing on oil refinery systems.
1981 & 1982 (Summers)	O.S. Anderson Engineering, Inc., *New Prague, MN.* Assistant Engineer. Designed software for and compiled data of E-fields generated by high voltage transmission lines, assisted in investigations of various cases involving questions of product liability.
PROFESSIONAL AFFILIATIONS:	Member Institute of Electrical and Electronic Engineers (IEEE) Member National Society of Professional Engineers (NSPE) Member Minnesota Society of Professional Engineers (MnSPE) Member International Association of Arson Investigators (IAAI) Member National Fire Protection Association (NFPA) Member National Association of Fire Investigators (NAFI) Member American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE)
EXPERT TESTIFYING WITNESS:	Arbitrations: 02 Depositions: 85 Trials: 26

ANDERSON DEPOSITION EXHIBIT 7

Nov 11, 2021, 07:15am EST | 489 views

EMI Shielding Technology: The Industries It Touches And Why You Should Care

Jack Kavanaugh Forbes Councils Member
Forbes Technology Council COUNCIL POST | Membership (Fee-Based)
Innovation

Chairman, CEO and co-founder of Nanotech Energy.

GETTY

EMI shielding is everywhere. Most business leaders, however, haven't given much thought to EMI shielding and likely couldn't define the technology if pressed. The same people have probably contemplated the dangers of living or working near electric power lines. They may also have read stories about

cell phone emissions and wondered if they needed to protect themselves (they don't).

EMI shielding — using a barrier to reduce electromagnetic radiation within a space — plays a bigger role in our day-to-day lives and is utilized by more industries than you might expect. EMI shielding uses substances like copper, graphene, paint and even fabric to create a protective barrier around a device and nullify radiation. The market demand for EMI shielding technology is surging. A 2020 study found that the global EMI shielding market will grow from $6.2 billion in 2021 to $7.7 billion in 2026.

EMI shielding isn't a niche technology or something that might catch on. It's a big business with opportunities and applications in many industries. Chances are you're already using it without even realizing it. Here are five key industries where EMI shielding is used — and why it's critical to our future.

1. Consumer Electronics

Most of us are exposed to EMI shielding technology via consumer electronics. A recent Markets & Markets report states that the EMI shielding business is growing exponentially because of consumer electronics and networks. Smartphones use innocuous EMI shielding to block electromagnetic radiation and eliminate interference to phones. EMI shielding is also critical for many wearables, which do everything from tracking your pulse or hours of sleep to counting the number of daily steps you take. Companies are working with modified fabrics that can block electromagnetic rays, which could be the next level of wearable tech. The more our world continues on a path where many people have a nearly symbiotic relationship with their electronics and consumer technology, the more critical EMI shielding becomes.

Forget The MacBook Pro, Apple Has Bigger Plans

Google Discounts Pixel 6, Nest & Pixel Buds In Limited-Time Sale Event

2. Telecommunications

Chances are you've driven past a cell tower trying to pass itself off as a tree. These towers have become more ubiquitous as we require robust digital networks — there were more than 417,000 cell towers in the U.S. as of 2020. The cell phones and wearables we all depend on would not work without access to wireless networks. EMI shielding makes sure radiation from wireless cell towers is kept in check, and that network interruptions are infrequent. 5G networks, for example, are built on delicate systems that must be protected. EMI shielding can prevent damage to the networks, whether from radiation or the environment (outdoor EMI shielding does both). This protective shield means fewer service interruptions and better connections — for streaming that 4K HD movie at home.

3. Cars And Airplanes

If you've purchased a vehicle in the past five years, it doesn't resemble the old Honda you had in the garage in the 1990s. A high-tech 2021 car features a GPS, satellite radio and Bluetooth, all of which allow you to connect your phone and devices and more. None of these devices could work well in your car without EMI shielding, especially since they also compete with electromagnetic rays from other passengers' laptops, smartphones and iPads. EMI shielding allows a technological symphony to take place each time you put your keys in the ignition or work on your laptop in-flight. EMI shielding is also essential for electric vehicles, which are, according to SSP, Inc., "more susceptible to electromagnetic interference" than gas-operated vehicles "because they put significant amounts of electrical and electronic content into confined spaces." Performance, as well as safety, can decline in the absence of proper EMI shielding.

While you probably haven't been in the cockpit of a plane since you were a kid, EMI shielding is also critical for airplanes. Airplanes have always needed to ensure that nothing interferes with vital navigating technology. Shielding is an even more significant concern as airplanes now compete with far more signals via consumer technology. EMI shielding is a foundational piece of safe airline travel.

4. Defense

It's no surprise that the defense industry is one of the key buyers of EMI shielding. Technology like drones, military computers and even equipment like tanks and helicopters emit a massive volume of electromagnetic radiation. These devices and vehicles are responsible for protecting military service members and sensitive data, so seamless operations are paramount. EMI shielding allows it to happen.

5. Wind Turbines And Electrical Grids

EMI shielding also helps protect wind turbines and the electrical grid. The company of which I am Chairman and CEO, Nanotech Energy, has designed

an EMI shielding paint for turbines that can reduce electromagnetic interference, as well as prevent overheating.

The Future Of EMI Shielding

While EMI shielding is paramount across industries, challenges are ahead. Companies design new consumer technology every day. It will be a race to ensure proper EMI shielding is available for the constant churn of new tech products and vehicles. Additionally, EMI shielding companies must continue to innovate — the paint shielding mentioned above is an excellent example of the next level of development.

EMI shielding may still be unknown to a vast number of the population, but expect it to come into much greater focus in the coming years, both as a business story and a necessity. It's not just a nice extra; it's the technology "glue" that allows our connected lives to take place safely each day.

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Follow me on LinkedIn. Check out my website.

Jack Kavanaugh

Chairman, CEO and co-founder of Nanotech Energy. Read... **Read More**

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MENU

ANDERSON DEPOSITION EXHIBIT 8

(/wps/portal)

Power Quality

Protect your electronic equipment from power interruption, before you make the power connection.

Central Maine Power is proud of its reputation for providing safe, reliable, electric power. However, severe storms, lightning, high winds, power equipment failures, cars hitting utility poles - even small animals climbing on utility wires - can cause power line disturbances.

Electrical load changes within your facility can also affect the quality of power. There are a number of things you can do to protect your sensitive electronic equipment from power disturbances. This information has been prepared to help you understand the causes and results of these disturbances and how to protect against them.

Equipment in your home or office that can be affected includes computers, digital clocks, answering machines, VCR's, electronic cash registers and security systems. Other equipment impacted by power quality problems include energy management systems, variable speed drives and phone systems.

Most electrical devices can tolerate short-term power disturbances without any noticeable effects. However, more serious power disturbances can cause data loss, memory loss, altered data, product loss, and other functional errors-as well as

equipment damage. These problems often cause expensive downtime, inefficiency, lost orders, scheduling problems and accounting problems. It is often necessary to troubleshoot to determine the cause of these problems. Having the right kind of power protection for your electronic systems becomes more important every day. It is difficult to predict when a minor power-related problem might become a major problem for your home or business.

Identifying the Problems

Since power disturbances are almost always intermittent problems, they can be difficult to identity.

Once a problem has been isolated as a power problem, it is important to identify the type of power disturbance so that the cause can be found and a solution can be implemented. Sometimes identifying the cause of a power disturbance can point to a low or no-cost solution.

Phase Protection

The kind of protection you need depends on the type of equipment you have and how you operate. Faults, which occur on the utility system or within your facility's distribution network, may be caused by squirrels, birds, auto accidents, tree branches, overloads or other occurrences that trip a protective device. When faults occur, one, two, or all three phases of your electrical supply may be affected. However, you may not notice when only one phase is interrupted, a condition known as "single phasing".

During single phasing, motors and other equipment may continue to run, but excessive current will flow in the two energized phases causing motors to overheat and possibly burn out. The only way single phasing can be identified quickly, before equipment is damaged, is to install a monitoring system to alert you. If you wait until you notice that your equipment is overheating, most likely the damage has already been done.

The National Electrical Code requires that three-phase motors and equipment have adequate electrical protection against power disturbances or interruptions. CMP's customers are responsible for installing single phasing and ground fault protection for three-phase equipment to prevent damage in the event of a disturbance or interruption. Without proper protection, disturbances or interruptions, known as faults, may damage three-phase motors and equipment.

CMP strongly recommends that you review your motor protection with an electrician, the equipment manufacturer, or a consulting engineer to ensure that your equipment has the proper protection. The protective equipment should be sensitive enough to detect abnormal voltage conditions on any or all phases.

Types of Disturbances

There are three types of irregularities, which could affect your power supply:

1. Voltage fluctuations
2. Switching transients
3. Power outages

Electrical Noise

Electrical noise is any unwanted signal traveling on electrical wires. Electrical noise can be caused by radio transmitters, fluorescent lights, computers, business machines, motors, dc drives, arc welders, heavy equipment, load switching, and loose electrical connections. Although some electronic equipment does have internal noise filtering capability, equipment located in very noisy environments may still encounter interference, such as glitches or malfunctions with computer, electronic, and communications equipment.

Electrical noise generators cause harmonic currents. Harmonic currents are currents that alternate faster than (on a frequency greater than 60 Hz) the standard current most equipment is designed for. These faster alternating currents appear as electrical noise to other devices on the same circuit. The only way to get rid of electrical noise is through the use of "dedicated circuits" and/or appropriate filtering equipment discussed later. IEEE Standard 519-1992 provides allowable harmonic limits for both customers and the utility.

Power Outages

Power Outages, often referred to as Power Interruptions, can best be defined as a complete loss of voltage for a few seconds or longer. Sensitive electronic equipment generally does not respond well to any type of power interruption.

Momentary (short duration) Outages generally range from less than one cycle to a few seconds. If the momentary interruption is caused by an event outside of ones home or business, the interruption is likely caused by a device known as a recloser.

A recloser turns off the power in response to a short circuit or an electrical fault on the utility system, commonly referred to as the power line. These faults are often caused by trees or animals coming into contact with the utility system. Though momentary outages are considered a nuisance, reclosers provide many benefits. In addition to protecting the public and utility personnel, reclosers are designed to reenergize the utility system if the fault was able to clear. This feature reduces the frequency of extended power outages.

Extended power outages are caused by larger scale problems, such as trees coming down on the utility system during a storm or vehicular accidents. The duration of the outage will vary based on the extent of the damages.

Power Protection: What you can do

Dedicated Circuit-Investigate Installing a Dedicated Circuit: computer equipment should be served from dedicated circuits that serve only computers. The dedicated circuit, with an insulated ground, should originate from the main switch. The dedicated circuit will reduce voltage fluctuations caused by other equipment.

When a variety of equipment shares a circuit, voltage fluctuations may be caused by the equipment switching on and off. By putting more sensitive equipment on its own circuit, you reduce the wear and tear and help to ensure the quality of power to that equipment.

There are two main categories of power protection equipment: power enhancement and power synthesis. Power enhancement equipment modifies and improves the incoming power while power synthesis equipment utilizes the incoming power as an energy source to create “new” power.

Power Enhancement

Power enhancers refine incoming power through a filtering process and work to overcome transient power problems. In many cases, different types of power enhancement devices are used in conjunction with one another to be sure that electrical problems are reduced or eliminated. Examples of power enhancers include:

Surge Suppressors

These units protect against transients by reducing high-voltage impulses to a level that is safe for your equipment. Surge suppressors can cope effectively with virtually any transients, although actual capability depends on the quality of the unit. Because surge suppressors are relatively inexpensive, it makes sense to install them as insurance against potential equipment damage, particularly from lightning strikes.

CMP recommends installing a quality surge suppressor that has a UL listing, and a UL Standard 1449 voltage “clamping” label. The best units can “clamp” a voltage transient to under 300 volts. The surge suppressor must clamp transients between line to neutral and neutral to ground. This level of protection is adequate for most applications.

Filters

Power line filters are the most widely used method for electrical noise reduction. A filter would be designed for a specific electrical noise problem. The design of the filter may require technical assistance from the equipment manufacturer or a power quality consultant.

Voltage Regulators

Quality voltage regulators maintain voltage output within narrow limits in spite of wide input fluctuations.

Isolation Transformers

These units are specifically designed to prevent electrical noise from being passed through to the protected equipment.

Power Conditioners

Hybrid power conditioners combine two or more functions in one device. A power conditioner will combine the advantages of both voltage regulators and isolation transformers. Some may also add surge protection. The term “power conditioner” is applied rather loosely, so study the manufacturer’s technical literature before you buy to be sure the product is capable of performing properly for your situation.

Power Synthesis

Power synthesis takes utility power and changes or synthesizes it into "new," undistorted power. Since this is a much more complex process, these devices are more expensive than power enhancers. Example of power synthesizers include:

Magnetic Power Synthesizer

This is a magnetic ferroresonant system made up of transformers, inductors and capacitors that reconstruct the desired AC output. This new output is free from all power line disturbances. These units do not store power, so they cannot protect sensitive equipment from outages.

Motor-Generator

This system buffers power to sensitive equipment by virtually regenerating it. It uses utility power to drive a motor, which, in turn, drives a generator, which provides electricity to the electronic equipment. Because motor-generators isolate the incoming power source from the eventual recipient of the power, they deal effectively with noise and transients on the incoming power supply. Motor-generators provide "ride-through" of momentary power interruptions up to one-half second, with actual capability varying with the design of the unit.

Uninterruptible Power Source (UPS)
Standby Power Source (SPS)

Although both an uninterruptible power source (UPS) and a standby power source (SPS) protect against blackouts, the cost and the degree of protection they provide differ considerably. A true UPS is always on-line, providing continuous, regulated and noise-free power under all AC-line conditions. An SPS, on the other hand, is always off-line and switches on-line only when AC power is lost. In fact, an SPS is sometimes called an off-line UPS.

An alternate power source, like a UPS, contains a battery and an inverter to convert DC to 120 volts AC. But that's where the similarities end. An SPS also has a transfer switch. Normally, the inverter is at rest and the primary AC power passes through the switch to the equipment. However, when the AC voltage drops below a pre-set transfer point, the transfer switch transfers the load to the output of the inverter, which then supplies 120 VAC power to the equipment.

Several factors must be considered before selecting a UPS or SPS. If a power outage is the only problem to be rectified, an SPS provides the most economical solution. As a minimum, the SPS should meet the IEEE 587 standard.

However, if voltage fluctuations occur frequently (causing havoc with a computer being used in a more critical application) a UPS is the best choice.

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Erik S. Anderson, PE, CFEI

Licensed in the States of MN, IL, WI, IN, IA, NM, TX, CA, LA, AZ & KY

Licensed Class A Master Electrician

Testifying Expert Witness

Anderson Engineering™
of New Prague Inc.

ANDERSON DEPOSITION EXHIBIT 9

EDUCATION

- B.S. in Electrical and Electronic Engineering
  North Dakota State University, Fargo, ND, 1987
- Chemical Engineering Course Work
  U. of Minnesota, Minneapolis, MN, 1981-83

FORENSIC EXPERIENCE

- Professional Engineering Services
- Electrical and Safety Code Interpretation
- Construction Defect Claims
- Electrical Fire and Accident Analysis
- Failure Mode Investigations
- Personal Injuries – Electrical in Nature

CONTINUING EDUCATION

- HAZWOPER 40 hour certification: 11/2008
- HAZWOPER 8 hour refresher course: 11/09, 11/10, 11/11, 11/12
- Asbestos Awareness: 05/09
- Instructor-Fire Investigation Seminar, Maricopa, AZ: 04/08, 03/09, 03/11, 03/12
- Instructor-Fire/Arson Level 3, Mesa, AZ: 10/03
- Instructor-Electrical Appliance Fires, IL Chapter IAAI Seminar: 2/03
- Minnesota Electrical Association Code and Code Change – National Electrical Code: 1/99, 2/01, 1/03, 1/05, 1/07, 1/09, 1/11, 1/13
- Fire and Arson Investigations, MN Chapter of IAAI: 3/88, 3/89, 3/90, 3/01, 3/05, 3/06
- Fire and Arson Investigations, IL Chapter of IAAI: 9/99

PROFESSIONAL AFFILIATIONS

- Member Institute of Electrical and Electronic Engineers (IEEE)
- Member National Society of Professional Engineers (NSPE)
- Member Minnesota Society of Professional Engineers (MnSPE)
- Member International Association of Arson Investigators (IAAI)
- Member National Fire Protection Association (NAFI)
- Member American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE)

NSPE® NATIONAL SOCIETY OF PROFESSIONAL ENGINEERS

Code of Ethics for Engineers

ANDERSON DEPOSITION EXHIBIT 10

Preamble

Engineering is an important and learned profession. As members of this profession, engineers are expected to exhibit the highest standards of honesty and integrity. Engineering has a direct and vital impact on the quality of life for all people. Accordingly, the services provided by engineers require honesty, impartiality, fairness, and equity, and must be dedicated to the protection of the public health, safety, and welfare. Engineers must perform under a standard of professional behavior that requires adherence to the highest principles of ethical conduct.

I. Fundamental Canons

Engineers, in the fulfillment of their professional duties, shall:

1. Hold paramount the safety, health, and welfare of the public.
2. Perform services only in areas of their competence.
3. Issue public statements only in an objective and truthful manner.
4. Act for each employer or client as faithful agents or trustees.
5. Avoid deceptive acts.
6. Conduct themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession.

II. Rules of Practice

1. **Engineers shall hold paramount the safety, health, and welfare of the public.**
   a. If engineers' judgment is overruled under circumstances that endanger life or property, they shall notify their employer or client and such other authority as may be appropriate.
   b. Engineers shall approve only those engineering documents that are in conformity with applicable standards.
   c. Engineers shall not reveal facts, data, or information without the prior consent of the client or employer except as authorized or required by law or this Code.
   d. Engineers shall not permit the use of their name or associate in business ventures with any person or firm that they believe is engaged in fraudulent or dishonest enterprise.
   e. Engineers shall not aid or abet the unlawful practice of engineering by a person or firm.
   f. Engineers having knowledge of any alleged violation of this Code shall report thereon to appropriate professional bodies and, when relevant, also to public authorities, and cooperate with the proper authorities in furnishing such information or assistance as may be required.
2. **Engineers shall perform services only in the areas of their competence.**
   a. Engineers shall undertake assignments only when qualified by education or experience in the specific technical fields involved.
   b. Engineers shall not affix their signatures to any plans or documents dealing with subject matter in which they lack competence, nor to any plan or document not prepared under their direction and control.
   c. Engineers may accept assignments and assume responsibility for coordination of an entire project and sign and seal the engineering documents for the entire project, provided that each technical segment is signed and sealed only by the qualified engineers who prepared the segment.
3. **Engineers shall issue public statements only in an objective and truthful manner.**
   a. Engineers shall be objective and truthful in professional reports, statements, or testimony. They shall include all relevant and pertinent information in such reports, statements, or testimony, which should bear the date indicating when it was current.
   b. Engineers may express publicly technical opinions that are founded upon knowledge of the facts and competence in the subject matter.
   c. Engineers shall issue no statements, criticisms, or arguments on technical matters that are inspired or paid for by interested parties, unless they have prefaced their comments by explicitly identifying the interested parties on whose behalf they are speaking, and by revealing the existence of any interest the engineers may have in the matters.
4. **Engineers shall act for each employer or client as faithful agents or trustees.**
   a. Engineers shall disclose all known or potential conflicts of interest that could influence or appear to influence their judgment or the quality of their services.
   b. Engineers shall not accept compensation, financial or otherwise, from more than one party for services on the same project, or for services pertaining to the same project, unless the circumstances are fully disclosed and agreed to by all interested parties.
   c. Engineers shall not solicit or accept financial or other valuable consideration, directly or indirectly, from outside agents in connection with the work for which they are responsible.
   d. Engineers in public service as members, advisors, or employees of a governmental or quasi-governmental body or department shall not participate in decisions with respect to services solicited or provided by them or their organizations in private or public engineering practice.
   e. Engineers shall not solicit or accept a contract from a governmental body on which a principal or officer of their organization serves as a member.
5. **Engineers shall avoid deceptive acts.**
   a. Engineers shall not falsify their qualifications or permit misrepresentation of their or their associates' qualifications. They shall not misrepresent or exaggerate their responsibility in or for the subject matter of prior assignments. Brochures or other presentations incident to the solicitation of employment shall not misrepresent pertinent facts concerning employers, employees, associates, joint venturers, or past accomplishments.
   b. Engineers shall not offer, give, solicit, or receive, either directly or indirectly, any contribution to influence the award of a contract by public authority, or which may be reasonably construed by the public as having the effect or intent of influencing the awarding of a contract. They shall not offer any gift or other valuable consideration in order to secure work. They shall not pay a commission, percentage, or brokerage fee in order to secure work, except to a bona fide employee or bona fide established commercial or marketing agencies retained by them.

III. Professional Obligations

1. **Engineers shall be guided in all their relations by the highest standards of honesty and integrity.**
   a. Engineers shall acknowledge their errors and shall not distort or alter the facts.
   b. Engineers shall advise their clients or employers when they believe a project will not be successful.
   c. Engineers shall not accept outside employment to the detriment of their regular work or interest. Before accepting any outside engineering employment, they will notify their employers.
   d. Engineers shall not attempt to attract an engineer from another employer by false or misleading pretenses.
   e. Engineers shall not promote their own interest at the expense of the dignity and integrity of the profession.
   f. Engineers shall treat all persons with dignity, respect, fairness, and without discrimination.
2. **Engineers shall at all times strive to serve the public interest.**
   a. Engineers are encouraged to participate in civic affairs; career guidance for youths; and work for the advancement of the safety, health, and well-being of their community.
   b. Engineers shall not complete, sign, or seal plans and/or specifications that are not in conformity with applicable engineering standards. If the client or employer insists on such unprofessional conduct, they shall notify the proper authorities and withdraw from further service on the project.
   c. Engineers are encouraged to extend public knowledge and appreciation of engineering and its achievements.
   d. Engineers are encouraged to adhere to the principles of sustainable development[1] in order to protect the environment for future generations.
   e. Engineers shall continue their professional development throughout their careers and should keep current in their specialty fields by engaging in professional practice, participating in continuing education courses, reading in the technical literature, and attending professional meetings and seminar.

3. Engineers shall avoid all conduct or practice that deceives the public.
   a. Engineers shall avoid the use of statements containing a material misrepresentation of fact or omitting a material fact.
   b. Consistent with the foregoing, engineers may advertise for recruitment of personnel.
   c. Consistent with the foregoing, engineers may prepare articles for the lay or technical press, but such articles shall not imply credit to the author for work performed by others.

4. Engineers shall not disclose, without consent, confidential information concerning the business affairs or technical processes of any present or former client or employer, or public body on which they serve.
   a. Engineers shall not, without the consent of all interested parties, promote or arrange for new employment or practice in connection with a specific project for which the engineer has gained particular and specialized knowledge.
   b. Engineers shall not, without the consent of all interested parties, participate in or represent an adversary interest in connection with a specific project or proceeding in which the engineer has gained particular specialized knowledge on behalf of a former client or employer.

5. Engineers shall not be influenced in their professional duties by conflicting interests.
   a. Engineers shall not accept financial or other considerations, including free engineering designs, from material or equipment suppliers for specifying their product.
   b. Engineers shall not accept commissions or allowances, directly or indirectly, from contractors or other parties dealing with clients or employers of the engineer in connection with work for which the engineer is responsible.

6. Engineers shall not attempt to obtain employment or advancement or professional engagements by untruthfully criticizing other engineers, or by other improper or questionable methods.
   a. Engineers shall not request, propose, or accept a commission on a contingent basis under circumstances in which their judgment may be compromised.
   b. Engineers in salaried positions shall accept part-time engineering work only to the extent consistent with policies of the employer and in accordance with ethical considerations.
   c. Engineers shall not, without consent, use equipment, supplies, laboratory, or office facilities of an employer to carry on outside private practice.

7. Engineers shall not attempt to injure, maliciously or falsely, directly or indirectly, the professional reputation, prospects, practice, or employment of other engineers. Engineers who believe others are guilty of unethical or illegal practice shall present such information to the proper authority for action.
   a. Engineers in private practice shall not review the work of another engineer for the same client, except with the knowledge of such engineer, or unless the connection of such engineer with the work has been terminated.
   b. Engineers in governmental, industrial, or educational employ are entitled to review and evaluate the work of other engineers when so required by their employment duties.
   c. Engineers in sales or industrial employ are entitled to make engineering comparisons of represented products with products of other suppliers.

8. Engineers shall accept personal responsibility for their professional activities, provided, however, that engineers may seek indemnification for services arising out of their practice for other than gross negligence, where the engineer's interests cannot otherwise be protected.
   a. Engineers shall conform with state registration laws in the practice of engineering.
   b. Engineers shall not use association with a nonengineer, a corporation, or partnership as a "cloak" for unethical acts.

9. Engineers shall give credit for engineering work to those to whom credit is due, and will recognize the proprietary interests of others.
   a. Engineers shall, whenever possible, name the person or persons who may be individually responsible for designs, inventions, writings, or other accomplishments.
   b. Engineers using designs supplied by a client recognize that the designs remain the property of the client and may not be duplicated by the engineer for others without express permission.
   c. Engineers, before undertaking work for others in connection with which the engineer may make improvements, plans, designs, inventions, or other records that may justify copyrights or patents, should enter into a positive agreement regarding ownership.
   d. Engineers' designs, data, records, and notes referring exclusively to an employer's work are the employer's property. The employer should indemnify the engineer for use of the information for any purpose other than the original purpose.

Footnote 1 "Sustainable development" is the challenge of meeting human needs for natural resources, industrial products, energy, food, transportation, shelter, and effective waste management while conserving and protecting environmental quality and the natural resource base essential for future development.

"By order of the United States District Court for the District of Columbia, former Section 11(c) of the NSPE Code of Ethics prohibiting competitive bidding, and all policy statements, opinions, rulings or other guidelines interpreting its scope, have been rescinded as unlawfully interfering with the legal right of engineers, protected under the antitrust laws, to provide price information to prospective clients; accordingly, nothing contained in the NSPE Code of Ethics, policy statements, opinions, rulings or other guidelines prohibits the submission of price quotations or competitive bids for engineering services at any time or in any amount."

Statement by NSPE Executive Committee

In order to correct misunderstandings which have been indicated in some instances since the issuance of the Supreme Court decision and the entry of the Final Judgment, it is noted that in its decision of April 25, 1978, the Supreme Court of the United States declared: "The Sherman Act does not require competitive bidding."

It is further noted that as made clear in the Supreme Court decision:

1. Engineers and firms may individually refuse to bid for engineering services.
2. Clients are not required to seek bids for engineering services.
3. Federal, state, and local laws governing procedures to procure engineering services are not affected, and remain in full force and effect.
4. State societies and local chapters are free to actively and aggressively seek legislation for professional selection and negotiation procedures by public agencies.
5. State registration board rules of professional conduct, including rules prohibiting competitive bidding for engineering services, are not affected and remain in full force and effect. State registration boards with authority to adopt rules of professional conduct may adopt rules governing procedures to obtain engineering services.
6. As noted by the Supreme Court, "nothing in the judgment prevents NSPE and its members from attempting to influence governmental action . . ."

Note: In regard to the question of application of the Code to corporations vis-a-vis real persons, business form or type should not negate nor influence conformance of individuals to the Code. The Code deals with professional services, which services must be performed by real persons. Real persons in turn establish and implement policies within business structures. The Code is clearly written to apply to the Engineer, and it is incumbent on members of NSPE to endeavor to live up to its provisions. This applies to all pertinent sections of the Code.

ANDERSON DEPOSITION EXHIBIT 11

Smart Meter Harm

Disabled rights, fires, overbilling, health problems, inaccuracy, hacking & cybersecurity, interference, privacy loss, and more....

Electrical engineer: The meter itself is the "hazardous" condition

Posted on May 31, 2019 by admin

From **Michigan Stop Smart Meters**

By William Bathgate, Electrical Engineer

October 12th, 2016

Revised October 13th, 2016

Editor's Note: In the following article, originally written as a public comment to the Michigan Public Service Commission, Mr. Bathgate considers safety issues with the new electric meters as related to our current discussion of a proposed rule change concerning emergency shutoffs for "hazardous conditions." Revisions to this article are indicated in blue and consist mainly in the addition of a section dealing with the lack of lightning arrestors in the AMI meters.

Case No. U-18120
Proposed Rule 460.137 — 37(1)(a) & 37(1)(i)

A utility may shut off or deny service to a customer "without notice, if a condition on the customer's premises is determined by the utility or a governmental agency to be hazardous."

I hold an electrical engineering and mechanical engineering degree and previously was employed through late 2015 for 8 years at the Emerson Electric Company. While at Emerson Electric I was the Senior Program Manager for Power Distribution Systems and in charge of an RF and IP based digitally controlled high power AC power switching system product line in use in over 100 countries and I was also directly responsible for product certifications such as UL, CE and many other countries electrical certification bodies. I am very familiar with the electrical and electronic design of the AMI meters in use because I was responsible for very similar products with over 1 Million units installed across the world.

I have just reviewed the transcripts of the hearing held in Lansing on this subject and came to realize there were many comments regarding the issues identified from the effects of both the RF emitting AMI meter and the non RF emitting AMI Opt-Out Meter. I have personally tested the RF emissions from the AMI meter and measured that the meter does not send data just a few times a day as the utilities publish. It actually sends an RF pulse about every 4-5 seconds constantly and a longer duration RF emission after midnight running about 3-5 minutes. There is no need for the AMI meter to send a pulse every 4-5 seconds all day just to synchronize and time stamp the clock inside the meter, the meter only needs to send data once a day for 3-5 minutes. All these pulse transmissions the AMI meter is doing is a complete waste of energy and because it is a short but frequently pulsing signal that is not needed to measure power consumption, it is creating needless health effects and is impacting consumers as evidenced in the testimony. Some consumers have been affected to the point of near death experiences. The Mesh Network design is saturating the

environment with RF transmissions mostly for the purpose of the network synchronization not the consumption measurement of power. I could not think of a worse network design for a power measurement device.

After reading the transcripts of the hearing I noticed quite a few comments from people affected to a terrible effect by the RF based AMI meter, and interestingly also the RF turned off Opt-Out Meter. It begs the question why do people also seem affected by the Opt-Out meter? Well I went out and purchased an ITRON

Open Way meter identical to the meter being deployed by DTE. I took the unit apart to examine the circuit design of the three boards inside the meter. Generally the boards seem well made with several important elements lacking or missing.

The switching mode power supply circuit is lacking effective Ground References, Lightning Protection and "Common Mode" EMI filters. The circuit boards are lacking a direct local connection to a Zero voltage potential ground at the meter to sink (ground) the current and voltage oscillations of the circuit boards.

Ground References:

Depending on the soil conditions and a solid or not solid low impedance connection ground point or surface, the ground plane reference (called a rotating return) of the circuit boards may be floating over a Zero voltage potential condition. This will create Electro-Magnetic Interference (EMI) via oscillation of the ground reference return paths. The use of no direct ground reference as in use today is a poor electrical practice with the AMI meter given all the environmental variables leads to a floating ground potential that could cause strong voltage and current ground potentials varying from zero to a worse case of 240 AC volts (due to a direct short). If there was a direct short of the feed wire because of a voltage surge on the input power from a power surge or lightning strike at the pole or where the two feed lines cross each other from a downed tree limb I would fully expect the circuit boards to likely explode or melt.

I have tested several homes for EMI created by the AMI meter and found that the ground environmental conditions dramatically affected the amount of EMI present. In one home I tested it had as a ground reference the copper water line feed from the city water supply. In this home there was very little EMI present as shown on my oscilloscope. In several another homes that had a standard 8 foot ground rod as the ground reference the EMI measured much, much higher. So there is a relationship of the AMI meter to the environmental reference to ground and EMI even though the circuit boards are not directly connected to a ground rod or ground reference. There was likely a magnetic coupling to earth ground taking place at the home using the water main as a ground reference. In all these homes all other lights, TV's, PC's, phone chargers etc. were disabled so I could avoid other variables affecting the readings. It goes to show that environmental variables can be very different from the test lab to the field environment.

Lightning:

First I have to say from my prior and current experience in very tall and large antenna arrays for the common house and business; lightning is very unpredictable and it is very costly to install effective lightning protection. Thankfully direct lightning strikes that are affecting the power feed and service entrance is random and less frequent. No commercial circuit board was ever designed to withstand a direct lightning strike. The US DoD has such designs but is very expensive to purchase. TV or commercial radio facilities have as much as $500,000 or more invested in lightning protection in order to stay on the air during a severe storm. All licensed amateur radio antennas are required by the FCC to have effective ground protection at the base of a tower to shunt a strike to ground. You are actually safer from lightning to be living close to a large metal antenna array because as a general rule lightning

tries to reach ground via the shortest and lowest impedance electrical path. It is not uncommon to see a lightning trace zigzag across an electrical path as it seeks the lowest impedance and shortest path to zero potential ground. Note I did not mention the potential for RF exposure which is a separate issue altogether! A neighbor's tall (over 30 Feet) metal antenna will be a shorter path to ground for lightning than your house next door.

In the AMI meter the circuit board that powers the solenoid actuator for the remote power disconnect feeding the power blade connection at the meter box is susceptible to the effects of lightning. When the low voltage DC power source on this circuit board becomes disrupted by a lightning strike and provided that the circuit boards survive the strike at all, this circuit board driven solenoid is subject to highly rapid disruption with a high frequency opening and closing of the remote disconnect contacts causing arcing and burnt contacts within the meter. This is completely undetectable by the consumer and may or may not manifest itself with flickering or dimming lights etc. The lightning may strike from two common sources; at the power pole or/and the surrounding ground area of the business or residence. The common person or business owner may not realize that the home or business ground rod reference wire runs in the middle between the two 240 volt AC power connections within the meter box and continues on to your entrance breaker panel. This is a minimal form of lightning protection because if the power pole gets hit by lightning the surge will likely jump the air gap between the two power line connections within the meter box and will shunt the lightning via the ground wire to the ground rod. Of course the meter and meter box itself may be damaged from this along with some of your internal house appliances etc. This ground connection was never meant to protect the meter box or your house internal wiring to survive a lightning strike; it is a power safety ground in case your internal house wiring or appliances have a direct short. Though not well known is that lightning can enter a building or home via your phone, DSL or Cable connections. I have learned from several catastrophic events by having my internet connections, TV's and PC's destroyed by a lightning strike many blocks away traveling these connections into the home. While I could not protect the DSL modem or cable modem from damage I could isolate the rest of my network with Ethernet Fiber Media converters. Once I did this I only lost the modem and nothing else downstream from it.

Analog Meters contained no electronic circuit boards and while not 100% immune from the effects of a lightning strike, they are much more tolerant than the AMI meter.

Common Mode EMI:

A "Common Mode" filter attenuates high frequency currents. A common mode filter in this case would look like two coils wrapped around an iron or iron ferrite core either in the shape of a donut or a small cookie bar. This filter is not present in the current circuit design and if it was there the switching circuit which converts 240 Volts AC to 5-10 volts DC would be prevented from sending EMI oscillations back onto the 240 Volt AC wires entering the home.

I am very familiar with the design elements of a switched mode power supply because I had to include "Common Mode" filters into the products I was responsible for while at Emerson Electric to minimize the Electro-Magnetic Interference (EMI) coming from the switching integrated circuit back onto the feeding input AC circuit and the output AC circuit. A clean 50 or 60 Hz is needed and the AC input and AC output had to be void of any oscillation introduced by the switching circuit. I would not have been able to sell the same ITRON switched mode circuit design with the products I managed. I would have been fired for allowing such a condition.

If DTE (or any Utility) was to demand of ITRON, their supplier, to provide a "Common Mode" filtering circuit and tested this design for elimination of EMI and of stray capacitance present in the current design, I believe the troubles with people becoming ill from the Opt-Out AMI meter could be significantly mitigated. This should not be ignored or taken lightly. There could be a solution to help the people affected by the high frequency oscillations created by the switched mode power supply.

In short lacking a redesign of the AMI meter switched mode power supply the solution for people affected by the AMI meter program is very simple and costs nothing, allow those affected residents and business to retain an Analog meter which is readily available and meets all ANSI and other applicable standards.

Summary:

The MPSC has been asked to grant the Utilities the ability to turn off power to people and businesses without notice for "Dangerous or Hazardous" conditions. Based on my professional examination of the metering technology deployed with AMI meters, the meters themselves are "Dangerous or Hazardous" due to their Lightning vulnerabilities, EMI and RF emissions. There has been a disregard for the health and safety effects of these AMI meters on the general population by the utilities and their AMI supplier. So by their own lack of definition of "Dangerous or Hazardous" all AMI meters deployed at present need to be subject to shut off of service without notice due to "Dangerous or Hazardous" conditions. This may be silly logic on my part but the logic of the proposed rule is equally silly logic and the rule change request should be denied due to lack of definition of what is "Dangerous or Hazardous". Based on my analysis of the AMI meter and the Analog meter the AMI meter is far more dangerous to the general population than the Analog meter.

In addition I think the MPSC should have a more active role in the technology decisions made by the utilities themselves. In the case of AMI meters the MPSC overlooked this responsibility to assure the utility monopolies are providing a safe metering technology to the consumer and businesses. Based on the effects on the population with people reporting near death experiences and crippling of their bodies with the AMI meters, this decision should be revisited by the MPSC in unison with the various groups that have reported serious issues with this technology. Otherwise the affected population at some time in the future will hold the MPSC directly accountable in a class action law suit which would have to be defended by the State of Michigan using scarce tax dollars for legal expenses. In the Flint Water Crisis the State of Michigan failed to provide proper governance and oversight of the water decisions in Flint costing the State of Michigan many hundreds of millions of dollars and it is far from settled yet.

Does the MPSC not see the similarities of Flint here with the AMI technology that has serious issues that can be simply solved? I do not want my tax dollars spent on defending the MPSC from a class action lawsuit. This requested rule set request is both deceptive and it is also obvious that the utilities want this rule provision to force every person to comply with whatever they want and bypass the MPSC to do it. This will permit the Utilities to use Social Media posts and other forms of protest criticizing them as a condition that is "Dangerous and Hazardous" and turn off power to shut people up and use the intimidation of shutoff of their power service without notice to deny them their first amendment rights. The public is not that stupid, significant numbers of the public knows the Utilities are going to use this tactic to force every home and business to have an AMI meter or else they will shut off their power without notice, even though there is no Federal or State law that specifically calls for an AMI meter. This AMI technology is specified in Federal law as a voluntary option for consumers not mandatory.

Forcing 100% compliance to AMI metering is not the solution; this will only lead to big legal troubles for the MPSC as a whole and direct legal liability to all individual MPSC members. Based on the testimony already made regarding AMI meter health issues the MPSC needs to step up and fulfill its charter to the residents of Michigan to provide SAFE and reliable power and not leave this to the sole discretion of the utilities. The current AMI meters are not safe, as evidenced of the dramatic testimony of residents that are suffering terribly and the engineering analysis such as I and many others in this field have performed.

If the MPSC approves these rule changes, then the MPSC should disband because your role in governance is of no value, merit or benefit to the citizens of the State of Michigan who are paying your salaries. You would have abrogated your governance role to the

utilities to do as they see fit for their own exclusive benefit and no one else.

[The Meter Itself is the "Hazardous Condition"]

This entry was posted in Uncategorized and tagged Bill Bathgate, emissions, hazard, health, llightning, Michigan, power consumptions, PSC, surge. Bookmark the permalink.

Smart Meter Harm

Blog at WordPress.com.

ANDERSON DEPOSITION EXHIBIT 12

ERIK S. ANDERSON

DATE	COURT	CASE NUMBER	DEPO/TRIAL
2021	In the Circuit Court of the Twelfth Judicial Circuit, Will County, Illinois	18 L 947	Deposition
2020	None	N/A	N/A
2019	In the Superior Court of the State of Arizona, In and for the County of Maricopa	CV 2017-012355	Trial
2018	In the Circuit Court of the State of Wisconsin In and for the County of Eau Claire	16-CV-31	Deposition
	In the Superior Court of the State of Arizona In and For the County of Maricopa	CV 2016-014713	Deposition (Orig.) Deposition (Supp.)
2017	In the Superior Court of the State of Arizona In and For the County of Maricopa	CV 2016-050257	Deposition
	In the Superior Court of the State of California, In and For the County Solano	No. FCS048117	Deposition
	Before the Arizona Corporation Commission	Docket # E-01345a-16-0036 Docket # E-01345a-16-0123	Admin. Hearing Testimony
	In the Superior Court of the State of Arizona, In and For the County of Maricopa	CV 2015-005133	Deposition
2016	In the Iowa District Court For Johnson County	LACV076639	Deposition
2015	In the Superior Court of the State of Arizona, In and For the County of Coconino	CV 2012-00058	Deposition
	In the Iowa District Court For Osceola County	CV 03721	Deposition
	In the Superior Court of the State of Arizona, In and For the County of Maricopa	CV 2014-002738	Deposition
	In the Superior Court of the State of Arizona, In and For the County of Maricopa	CV 2013-005043	Deposition
2014	In the 61st Judicial District, Harris County, Texas	2011- 11182	Deposition/ Trial
2013	In the United States District Court, District of Arizona	3:11-cv-08086-NVW	Trial
	In the United States District Court, District of Arizona	CV-13-00242-PHX-NVW	Deposition

DATE	COURT	CASE NUMBER	DEPO/TRIAL
2012	In the Superior Court of the State of Arizona, in and For the County of Maricopa	CV 2009-033244	Deposition Trial
2011	In the Eighth Judicial District Court of the State of Nevada, In and For the County of Clark	A556883	Trial
	In the Superior Court of the State of Arizona, In and For the County of La Paz	CV 2010-00165	Deposition
	In the Circuit Court of Cook County, Illinois County Department – Law Division	No. 09 L 1022	Deposition
2010	In the United State District Court, Northern District of Texas, Wichita Falls Division	7:09-cv-00096	Deposition
	In the United States District Court, District of Nevada	2:09-CV-01304-RCJ-RJJ	Deposition
	In the Fourth Judicial District Court of the State of Minnesota, In and For the County of Hennepin	27 CV 07-002344	Trial
	In the Eighth Judicial District Court of the State of Nevada, In and For the County of Clark	A556883	Deposition
2009	In the Superior Court of the State of Arizona, In and For the County of Maricopa	CV 2008-051259	Deposition
	In the Superior Court of the State of Arizona, In and for the County of Maricopa	CV 2007-012799	Deposition
2008	In The Superior Court Of the State of Arizona, In and for the County Of Maricopa	CV 2005-006284	Deposition
	In the Superior Court Of the State of Arizona, In and for the County of Maricopa	CV2007-052523	Deposition
	In the Superior Court Of the State of Arizona, In and for the County of Coconino	CV 2005 0701	Deposition
	In the Superior Court Of the State of Arizona, In and for the County of Maricopa	CV2004-092571 con. w/ CV2005-091171	Deposition
	In the Superior Court Of the State of Arizona, In and for the County of Maricopa	CV 2005-053526	Deposition
2007	In the Superior Court Of the State of Arizona, In and for the County of Maricopa	CV 2007-000448	Deposition
	In the Superior Court of the State of Arizona, In and for the County of Yuma	S1400CV2005-00874	Deposition
	In the United States District Court, District of Arizona	2:06-CV-2168 PHX-FJM	Deposition

DATE	COURT	CASE NUMBER	DEPO/TRIAL
	In the Circuit Court of Cook County, Illinois, County Department – Law Division	04 L 2567	Deposition Trial
	In the Circuit Court of the Fifth Judicial Circuit, The Roberts County of South Dakota	CV 07-33	Deposition
	In the Circuit Court of Cook County, Illinois, County Department – Law Division	04 L 00098	Trial
	United State District Court, District of Arizona	CV 04 2936-PHX-RCB	Trial
	In the Superior Court of the State of Arizona, In and For the County of Maricopa	CV 2004-014969	Trial
	Superior Court of Arizona, Coconino County	CV 2004-0717	Deposition
	In the Superior Court of the State of Arizona, In and For the County of Maricopa	CV 2005-019020	Deposition
2006	In the Circuit Court of Cook County, Illinois, County Department – Law Division	03 L 005524 con. w/ 03 L 005519	Deposition
	In the Circuit Court of the Sixteenth Judicial Circuit, Kane County, Illinois	05 LK 264	Deposition
	In the Superior Court of the State of Arizona in and for the County of Maricopa	CV2004-014969	Deposition
	State of Wisconsin, Circuit Court, Barron County	04 CV 112	Deposition Arbitration
	In the Iowa District Court in and for Buchanan County	LACV005647	Deposition
	In the United States District Court, Northern District of Illinois, Eastern Division	03 C 50396	Deposition
	In the Circuit Court of Cook County, Illinois, County Department, Law Division	02 L 11489	Deposition
	26th Judicial District Court, Webster Parish, Louisiana	62,861-E	Deposition
	United States District Court, District of Arizona	CV'04 2936-PHX-RCB	Deposition
	In the Circuit Court of Cook County, Illinois, County Department, Law Division	03 L 15395	Deposition Trial
	In the Superior Court of the State of Arizona in and for the County of Maricopa	CV2005-008389	Deposition
	In the Superior Court of the State of Arizona in and for the County of Maricopa	CV 2004-020114	Deposition

DATE	COURT	CASE NUMBER	DEPO/TRIAL
	In the Circuit Court of the Twenty-First Judicial Circuit, The Iroquois County, Illinois	02-L-40	Deposition
2005	State of Wisconsin, Circuit Court, Barron County	04 CV 112	Deposition
	In the Superior Court for the State of Arizona in and for the County of Cochise County, Division 3	CV2001-00260	Trial
	In the Superior Court for the State of Arizona in and for the County of Maricopa	CV2003-009837	Deposition Deposition
2004	In the Circuit Court of the Third Judicial Circuit, Madison County, Illinois	02-L-666	Deposition Trial
	In the Circuit Court of the Nineteenth Judicial Circuit, Lake County, Illinois	02 L 979	Deposition
	State of Wisconsin Circuit Court Barron County	03 CV 95	Deposition
	In the District Court of Tulsa County State of Oklahoma	CJ-2001-05295	Deposition Trial
	State of Wisconsin Circuit Court Kenosha County	03-CV-000255	Deposition
	State of Minnesota District Court County of Ramsey Second Judicial District	62-C4-02-008560	Trial
2003	In The United States District Court Northern District of Illinois, Eastern Division	02 C 60413	Deposition
	State of Minnesota District Court County of Isanti, Tenth Judicial District	C6-99-1516	Deposition
	State of Minnesota District Court County of Carver First Judicial District	10C70000737	Deposition
	State of Wisconsin Circuit Court St. Croix County	01-CV-39	Testified-Arbitration
	In The Circuit Court of the Nineteenth Judicial Circuit, Lake County, Illinois	01 L 538	Deposition
2002	State of Illinois, County of Cook In The Circuit Court of Cook County, Illinois	00 L 001340	Deposition Deposition
	In The Circuit Court of Faulkner County, Arkansas Third Division	CIV 2001-705	Deposition
	United States District Court, District of Minnesota	01-2310	Deposition

DATE	COURT	CASE NUMBER	DEPO/TRIAL
	United States District Court District of Minnesota	01-140 DWF/RLE	Deposition Trial
	In The Circuit Court of Cook County, Illinois	99 L 01561	Deposition
2001	State of Minnesota District Court County of Carver First Judicial District	10C70000737	Deposition
	State of Wisconsin, Circuit Court Dane County	99-CV-2603 Code No. 30201	Deposition
	State of Minnesota, County of St. Louis	T3-99-604888	Trial
	United States District Court for the Northern District of Illinois	99 CR 381	Trial
2000	In The District Court of Hennepin County, Minnesota	PD 99-011626	Deposition
	State of Minnesota, District Court First Judicial District, County of LeSueur	C3-99-520	Deposition Trial
	State of Minnesota District Court County of Isanti, Tenth Judicial District	C6-99-1516	Deposition
	United States District Court District of Minnesota, Fourth Division	99-1128 DWF/ABJ	Deposition Deposition Deposition
	State of Minnesota, County of Stevens District Court, Eighth Judicial District	C3-98-227	Trial
	State of Minnesota, County of St. Louis, District Court, Sixth Judicial District	68-99-6000514	Trial
1999	State of Minnesota, County of St. Louis, District Court, Sixth Judicial District	68-99-6000514	Deposition Deposition
1998	State of Minnesota District Court, City of Todd, Seventh Judicial District	C1-97-590	Trial
	State of Wisconsin, Circuit Court, Rock County	950327-NO	Deposition
1997	State of Minnesota District Court, City of Todd, Seventh Judicial District	C1-97-590	Deposition
	State of Minnesota District Court, County of Winona, Third Judicial District	CO-94-1889	Deposition
	State of Illinois County of Cook in the United States District Court for the Northern District of Illinois, Eastern Division	90-C-2005	Trial

DATE	COURT	CASE NUMBER	DEPO/TRIAL
1996	State of Minnesota, Anoka County	C1-95-14926	Trial
	State of Illinois County of Cook in the United States District Court for the Northern District of Illinois, Eastern Division	90-C-2005	Deposition
	Circuit Court of the State of Michigan for the County of Cass	95-0327-NO	Deposition
1995	State of Minnesota, County of Hennepin District Court, Fourth Judicial District	93-19757	Deposition
	Circuit Court of the State of Wisconsin for the County of Milwaukee	92-C-015464	Deposition
1994	State of Minnesota, County of Becker District Court, Seventh Judicial District	CO-94-241	Deposition
	In the United States District Court, Northern District of Illinois, Eastern Division	93-C-3377	Deposition
	In the Circuit Court of Cook County, Illinois	89-L-2143	Deposition
1993	United States District Court, District of Minnesota	4-93-169	Deposition
	State of Wisconsin, Circuit Court, Dane County	92-CV-3115	Deposition
	State of Minnesota, County of Rice District Court, Third Judicial District, Category: Other Civil Declaratory Judgment	CX-91-1523	Trial
	In the United States District Court for the Western District of Missouri	92660-CV-W-1	Deposition
	In the United States District Court, Northern District of Illinois, Eastern Division	92-C-4692	Deposition
1992	State of Illinois, County of Cook in the Circuit Court of Cook County, Illinois County Department, Law Division	87-L-12719	Deposition Trial
1991	State of Illinois, County of Cook in the United States District Court for the Northern District of Illinois, Eastern Division	90-C-2005	Deposition
	In the United States District Court for the Southern District of Iowa, Central Division	Criminal No. 91-71	Trial

ANDERSON DEPOSITION EXHIBIT 13

Anderson Engineering of New Prague, Inc.
20526 330th Street
New Prague, MN 56071
507-364-7373
www.aenpi.com

Tax ID: 41-1601675

December 16, 2021

Ed Friedman
Ed Friedman
edfomb@comcast.net

Invoice Number: 1181

Payment Terms: Upon Receipt

RF Exposure / Smart Meter
Lead Engineer: Erik S. Anderson, P.E.
Our File No. 2021341

Time Details

Date	Timekeeper	Description	Hours	Rate	Amount
09-26-2021	Erik Anderson	Conversation with Ed Friedman. Discuss the matter, set up further conversations. Open file.	1.20	295.00	354.00
09-27-2021	Erik Anderson	Review materials and respond to email. Set up Zoom meeting.	0.40	295.00	118.00
09-28-2021	Erik Anderson	Zoom meeting with Ed Friedman and William Most. Set schedule for draft report. Engineering analysis.	0.80	295.00	236.00
10-26-2021	Erik Anderson	Review file materials, write and edit report. Engineering analysis.	0.60	295.00	177.00
10-28-2021	Erik Anderson	Review materials, write and edit report. Engineering analysis. Research.	1.10	295.00	324.50
10-29-2021	Erik Anderson	Write and edit report. Review supplied materials, engineering analysis.	2.00	295.00	590.00
10-30-2021	Erik Anderson	Write and edit report.	0.70	295.00	206.50
10-31-2021	Erik Anderson	Write and edit report, engineering analysis, research.	1.80	295.00	531.00
11-01-2021	Erik Anderson	Write and edit report, engineering analysis, research.	4.00	295.00	1,180.00
11-02-2021	Erik Anderson	Write and edit report. Send draft to client.	3.20	295.00	944.00
11-10-2021	Erik Anderson	Zoom meeting with William Most and Bruce Merrill regarding draft report. Engineering analysis.	1.50	295.00	442.50
11-15-2021	Erik Anderson	Conversation with Ed Friedman, send email with full court testimony attached, review and research documents, edit report, engineering analysis.	2.60	295.00	767.00
11-23-2021	Erik Anderson	Review and edit report. Engineering analysis.	3.00	295.00	885.00
11-25-2021	Erik Anderson	Review and edit report. Send report to counsel.	0.80	295.00	236.00
11-28-2021	Erik Anderson	Review report, edit report. Send report to counsel.	0.50	295.00	147.50

Date	Timekeeper	Description	Hours	Rate	Amount
			Total		7,139.00

Total for this Invoice	7,139.00